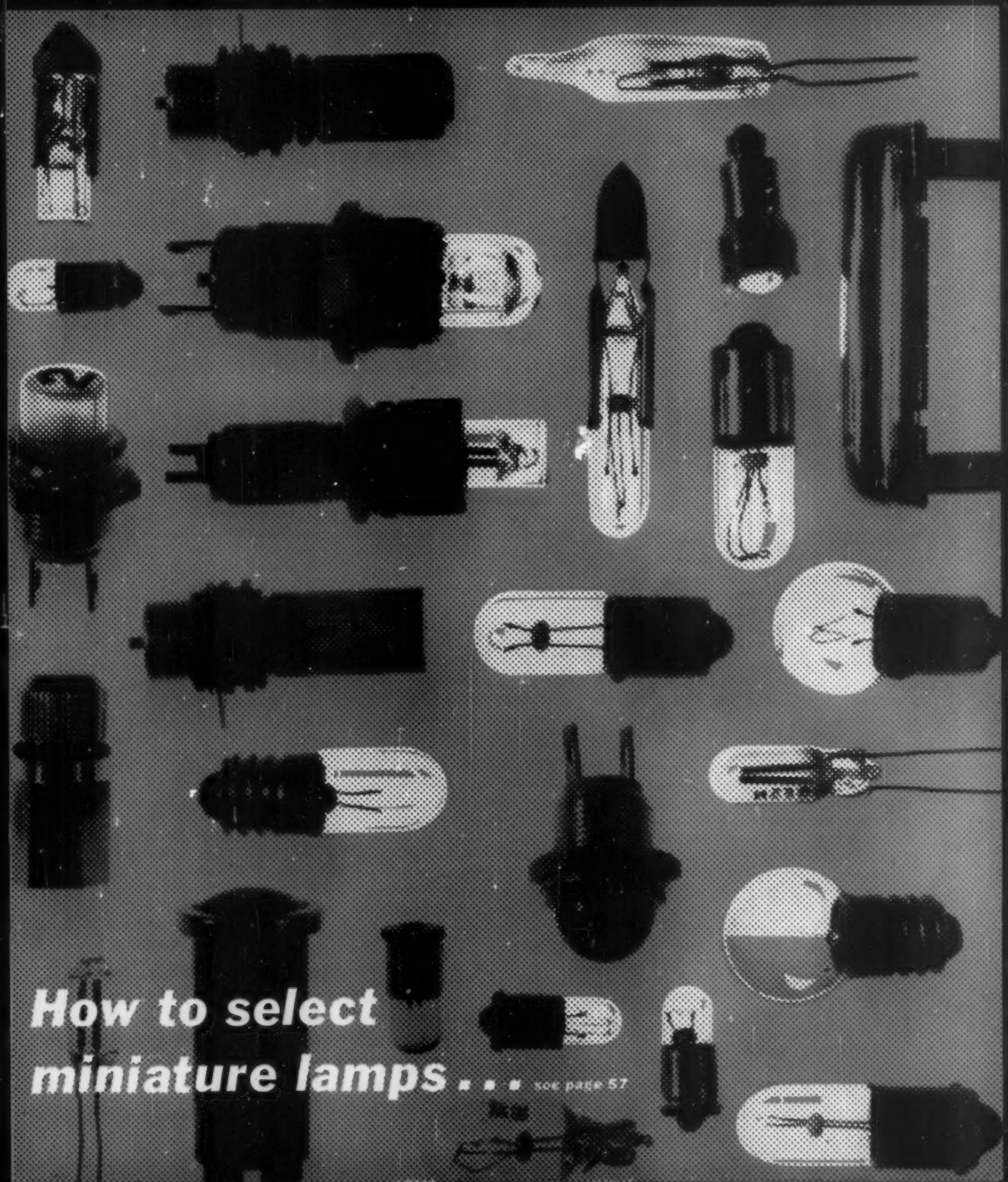
$3 A YEAR

PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT · JULY 18, 1960

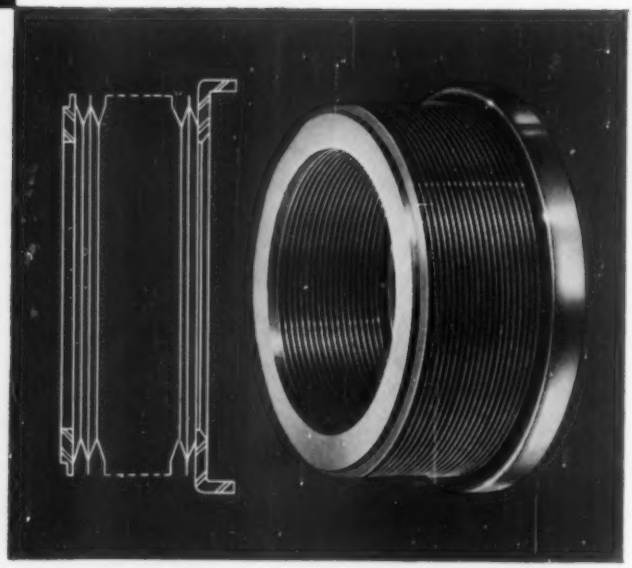


How to select miniature lamps . . .

see page 57

C/R DESIGN NOTES

How C/R's New Metal Bellows Seal Meets Seemingly Impossible Operating Conditions



Operating Ranges

Temperature	−400° to 1000° F.
Pressure	500 psi
R.P.M.	80,000 plus

These known operating ranges indicate the function of this seal. It is designed for applications where temperatures and mediums to be sealed forbid the use of any organic materials. Typically, these applications include fuel pumps, compressor power units and turbine starters characteristic in rockets and missiles. Other applications include mechanisms which are exposed to a high level of radioactivity.

Design Advantages

The C/R metal bellows seal consists of a metal bellows — a welded homogeneous unit which is secured at one end — and a carrier ring in which the sealing face is mounted. The seal does not contact the shaft. It is stationary, and the only rubbing surfaces are the sealing face and mating ring. These surfaces are precision lapped to provide a positive seal with minimum friction. At any given pressure, the seal can be designed to maintain proper and constantly effective face loads. It orients immediately to run-out and will resist any torques it is subjected to in operation. The design has high end-play tolerance: Chicago Rawhide engineers have deflected a bellows .100 in. for three million cycles at 1750 cpm and at a temperature of 500° F. with no adverse effects.

A further advantage is relatively light weight and compactness. The C/R metal bellows seal can be designed for minimum axial and radial space. Axially, complete seals can be produced within a ¼ in. cross-section. Radially, dimensions are comparable with conventional end face seals.

The C/R metal bellows seal can also be designed with an extremely low coefficient of expansion. The importance of this factor becomes apparent with the fact that in many applications the operating temperature may change hundreds of degrees in a very few seconds.

Mediums To Be Sealed

Virtually any known liquid or gas may be positively sealed with this design, depending upon duration or service life. From a practical viewpoint, the C/R metal bellows seal is the best design for the sealing of cryogenic and high-energy fuels such as LOX, hydrogen peroxide, fluorine and other missile and rocket propellants.

Where possible, lubrication of the two sealing faces is desirable to prolong service life. However, the medium being sealed commonly acts as the lubricant and may be merely hot gas.

Materials

Sealing faces and mating rings for the C/R metal bellows seal are available in a variety of materials including carbons, carbides, ceramics and various alloyed metals for both high temperature and corrosion resistance. The bellows can be furnished in any of several metals and alloys such as stainless steel, Monel, Inconel X, Ni-Span C and other special alloy steels.

Consult C/R Engineers

Each application for the C/R metal bellows seal is essentially a custom-design and an intimate knowledge of all conditions to be encountered must be known by Chicago Rawhide engineers to produce the correct combination of properties in the seal. Then, whether you require five, fifty or five thousand seals, Chicago Rawhide will design and produce the correct seal to solve your problem.

Helpful Design Data:

We will gladly furnish you with a design guide and space envelope data concerning the C/R Metal Bellows Seal. Just write for Bulletin MBS-1 on your company letterhead.

CHICAGO RAWHIDE MANUFACTURING COMPANY

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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

July 18, 1960 Vol. 31, No. 29

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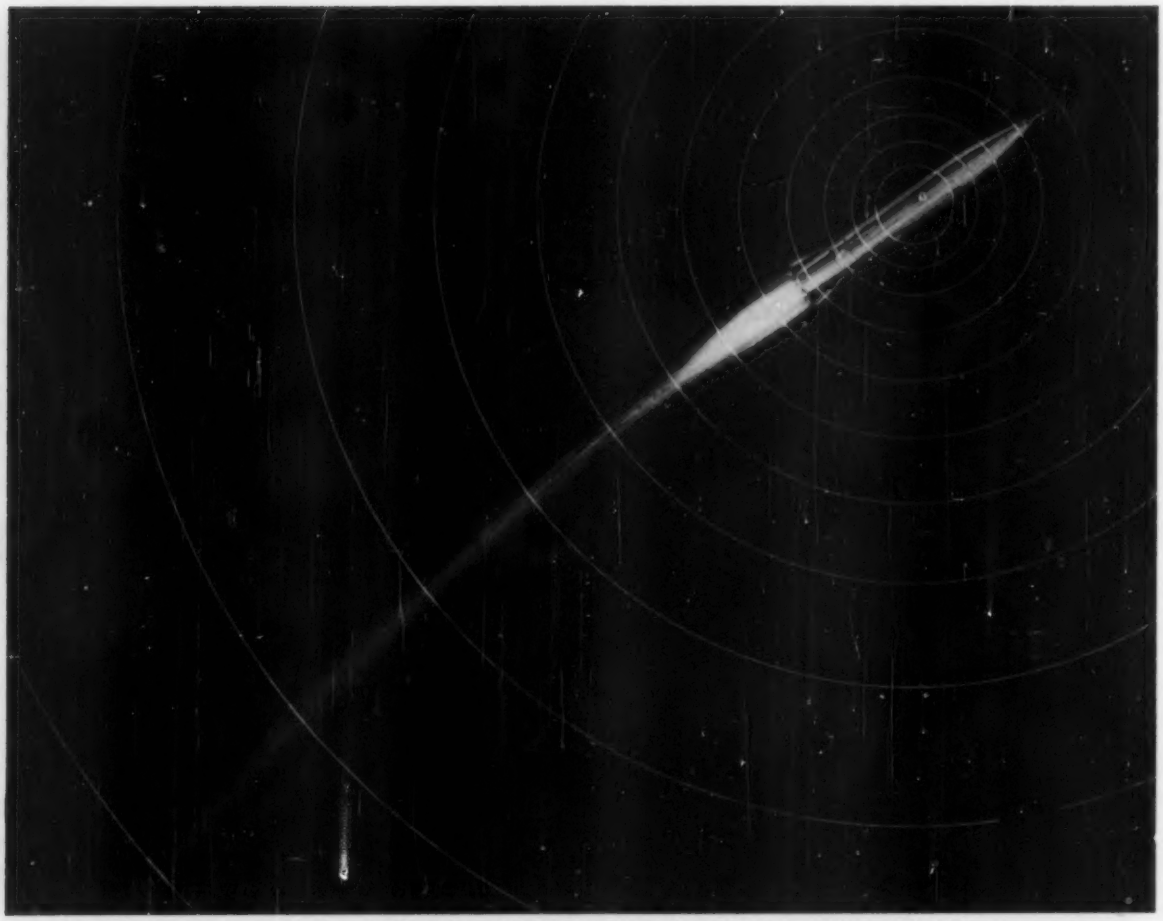


Things happen fast to a rocketing missile. High-nickel Mumetal shields help tape recorders get it all down accurately.

How Nickel helps record messages from space

When a missile rockets off into space, it detects all sorts of data – temperature, radiation, meteoric dust – the many things we need to know in order to conquer space.

Since radio transmission and reception between missile and ground is not always reliable, some missiles carry an airborne secretary–a multichanneled tape recorder.

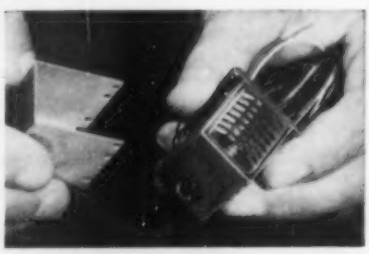
It records as many as thirty different bands of data side by side on a 1½-inch magnetic tape.

Confusion of all the magnetic fields crammed inside the tiny head could cause messages to come out garbled.

But there is a way to keep them straightened out–by using Mumetal* (77% Nickel). This alloy has the unusual ability of soaking up magnetic fields like a sponge. Thin, flat shields of Mumetal siphon off troublesome interference.

The manufacturer also covers the whole head with more Mumetal to bar stray magnetic fields on the outside from getting inside. And then a protective Nickel-chrome plating goes on top of that.

All in all, it's quite a job Nickel does. And something to keep in mind the next time you're faced with a problem in your product or process. If it has to do with high or low temperatures . . . magnetism . . . corrosion . . . fatigue or some other factor, write us. We'd be happy to show you how Nickel, or one of its alloys, may be able to help.



Tiny magnetic head of tape recorder has Mumetal shields to trap magnetic interference, help Davies Lab. Division of Minneapolis-Honeywell pack much in little space. Nickel-chrome plating on cover adds durability, corrosion resistance, and attractive appearance.

*Trademark, Allegheny Ludlum Steel Corporation

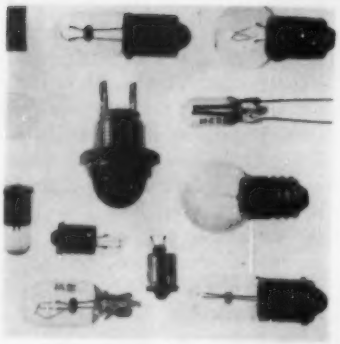
The International Nickel Company, Inc.

67 Wall Street INCO New York 5, N. Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

INTERESTING TO NOTE



On our cover—a selection of small lamp bulbs ranging all the way down to the needle's eye size. We had originally planned to photograph them when they were lit up, but the range of voltages would have required several different power supplies and a jungle of wires. These tiny bulbs give out surprisingly large amounts of light; however, their application may be more troublesome than you think. See p 57 for design pointers.

Developing a better light bulb from a sneeze doesn't happen often, but it did happen once. Thousands of people annually suffer from hay fever or related allergies. About fifteen years ago, a development engineer at Westinghouse decided between sneezes, to do something technological about it. He convinced his boss that if the company installed one of its new "precipitrons" in his office, his hay fever would improve. The device, which had been used to eliminate chimney smoke, relieved the engineer's hay fever so successfully that he began to think of possible applications of the same electrostatic principle to his development work on light sources.

He tried it on fluorescent lamps by making smoke out of the phosphor powder and electrostatically depositing it on the bulb. A large-scale development project followed, but after exhaustive tests, a liquid coating process won out by a small margin.

Undiscouraged, the engineer tried with the electrostatic principle to deposit a fine white powder on the inside of an incandescent bulb, replacing the standard inside frosting. Again a large-scale development project followed. There were many obstacles to overcome in selecting the right material and obtaining the high degree of light diffusion without absorbing additional light. But this project was successful, and the New-shape Eye Saving line of Westinghouse light bulbs resulted.

Degreeless Engineers

Dean James Kip Finch says in his new book, *The Story of Engineering*, "The engineer has been, and is, a maker of history." Dean Finch was a member of the faculty of the School of Engineering at Columbia Univ for 42 years and knows the importance education plays in molding the modern engineer. (For a young engineer's point of view on education and relativity, see p 24.) The fact that there are more engineers living today than in all the years of recorded history combined stresses the importance our society places on the profession. Unfortunately, we appreciate the profession, we cry for more engineers, but we're not willing to foot the bill for their education.

A college degree as an engineering prerequisite is a relatively new concept. Very few of our early engineers

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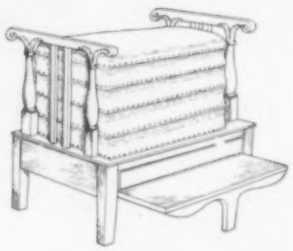
ever got close to a college, Eli Whitney being the exception (he graduated from Yale). Experience was the most important step to success in 18th and 19th century America, and experience came by starting as an apprentice. Benjamin Franklin, for example, started school at the age of eight and two years later he was on the road, selling soap—prior to becoming an apprentice printer. Joseph Henry was a storekeeper's apprentice until he was 16 years old—only then did he decide to enroll in night school. When he finally got to college it was as a lecturer, not a student. Cyrus McCormick never got past high school; Edison didn't get that far. George Westinghouse promised his father he'd attend college and he did so—for one year. The Wright family sent daughter Katherine off to Oberlin while Orville and Wilbur remained in Dayton repairing bicycles and designing airplanes.

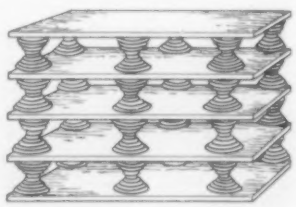
Bedtime Story

Comfort has been the goal of people for centuries. Yet when we look back and observe how our forefathers attempted to reach this goal we may utter a word of thanks every time we recline in our easy chair. The earliest beds were simply slabs of rock or clay covered with boughs or animal skins. Later, beds were made by interweaving wicker and palm fibers; leather thongs added resiliency. This type was used by the Egyptians and might have been comfortable had it not been for a wooden, saddle-shaped headrest that caused many a stiff neck.

During medieval days, protection at night must have been the fad. So many pillows and bolsters were used, the knight practically slept standing up. A sword was always hanging on a bedpost so the sleeper could immediately jump from bed and defend himself. By the time of the Renaissance, comfort was secondary; art was the thing. Beds and chairs were made of several dozen different woods—some inlaid with stone; others with metal. Some beds were enormous monstrosities surmounted by the plumage of tropical birds.

Then, in the early 18th century, a revolution occurred. Springs were applied to furniture. In 1706, an English patent was granted for "a mathematical instrument consisting of several springs, for the ease of persons riding in coaches, chairs and other conveyances." Years later, cabinetmaker Thomas Sheraton used springs in a "gymnastic chair." This predecessor of the hobby horse became quite popular with equestrians who couldn't take to the fields in bad weather. He built his "gymnastic chair" of "five wainscot boards clamped at the ends; to which is fixed strong wire twisted around a block in regular graduation, so that when the wire is compressed by those who exercise, each turn of it may clear itself and fall within each other." Like today's engineer, he was confronted with the problem of preventing his springs from buckling (see page 62). He solved this by using layers of springs separated by thin boards in what may have been our first "sandwich construction."





—Benedict A. Leerburger Jr

NEXT WEEK IN PRODUCT ENGINEERING

. . . Avoiding Metal-hose Failure

All the possible causes of failure, and how to overcome them.

. . . Challenge—the Speedup in Engineering

A look at some of the trends that have developed so far, plus opinions on the future.

. . . Guide to Specifying Metal-powder Parts

The cost of the part depends not only on the kind of powder, but on how much you can "dilute" it with air.

. . . 8 Ways to Guard Against Metal Whiskers

When conditions are right, some metals breed tiny hairlike growths, which can cause short circuits or low impedance.

. . . Equations for 5 Tapered Cantilever Beams

Calculating the stresses and deflections in these weight- and money-saving beams now require only simple algebra.

KCP SERIES KT SERIES KR SERIES

three for dependability at low cost

MEET P&B's FAMILY OF "K SERIES" RELAYS

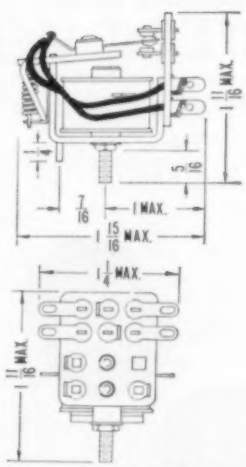
Here are only three of a large family of "K Series" relays by P&B. Blood brothers all, they are distinguished by fine craftsmanship and design maturity. Together they will handle a multitude of switching requirements.

Many design engineers find it saves time, saves money to integrate their circuits with *related* P&B relays. Makes sense, doesn't it?

KR—A small, lightweight relay used widely in communications and automation. Engineered for long life and dependability. 3PDT max. AC or DC. (See engineering data.)

KT—Designed for antenna switching. Capacitance: 0.5 mmfds between contacts. Terminal board is glass melamine and stack insulation is glass silicone for minimum RF losses to switch 300 ohm antenna line. 3 PDT max. AC or DC.

KC—Low cost plate circuit relay with sensitivity of 125 mw per pole. Factory adjusted to pull-in on specific current values. Available open, hermetically sealed or in clear plastic dust cover with standard octal-type plug. 3 PDT max. DC.



KR ENGINEERING DATA

GENERAL:
Breakdown Voltage: 500 volts rms minimum between all elements.

Temperature Range:
DC Coils—45°C to 85°C.
AC Coils—45°C to 70°C.

Terminals:
Pierced solder lugs standard. Octal 8 and 11 pin plug-in headers available.

Enclosures: Type K—Hermetically sealed.
Type P clear cellulose acetate dust cover.

CONTACTS:
Arrangements: 3 Form C (3PDT) max.
Material: ⅛" dia. fine silver (gold plated).
Other materials available to increase contact capacity.
Load: 5 amperes 115V 60 cycle resistive.

COILS:
Resistance: 16,500 ohms max. AC or DC.

Power: 1.1 watts minimum to 4 watts maximum for DC at 25°C ambient.

Duty: Continuous.
Insulation: Centrifically impregnated with insulating varnish.

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DEVELOPMENTS TO WATCH...

Danes develop overload protectors for solid-state rectifiers

Fast-acting overload fuses for silicon and germanium diodes have been developed by Lauritz Knudsen, Electrical Mfg Co Ltd, 53 Haraldsgade, Copenhagen.

These are not stock items; they are engineered for the job. It is especially important, says Knudsen, to choose a combination of melting time and arcing time which will minimize stress on the diodes.

Knudsen claims the devices show complete absence of voltage peaks. When the diode fuse melts "the arc voltage is established without transient overvoltages." Furthermore, says Knudsen, "it is usually possible to provide full protection for the diodes without resorting to short-circuiting devices."

Melting-time charts and other data are available in English.

Solid-state timers will control appliances

An electronic timer without motors, cams, or other mechanical components is being developed by Electronic Timers Co (a division of P R Mallory) as part of a fundamental long-range program aimed at producing new control systems.

The timer consists of an electronic clock that supplies a voltage pulse at time-spaced intervals, solid-state switching modules and power amplifiers, and a series of programing selector switches.

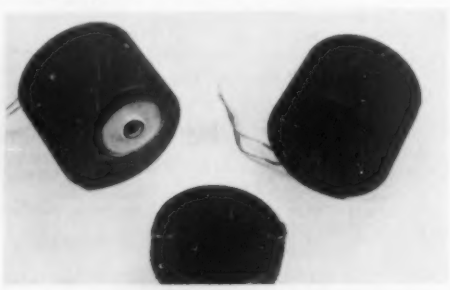
In its present stage of development, the timer is far too costly for general commercial application—production cost estimates run to about $100. But Mallory is confident that the basic idea is sound and that a practical, economical unit can be developed for such equipment as automatic washers.

Britons claim super plastics

High strength, light weight, and heat resistance to 1830 F are among the claims being made by Artrite Resins, Ltd of Surrey, England for the new series of resins it announced recently. Two types have been developed; one for temperatures to 930 F; the other, to reach the higher figure. Little information is yet available on what they are; but they probably are synthetic organic resins analogous to silicones, and based, perhaps, on phosphorus and boron (*PE*—May 23, p 10) instead of silicon and carbon. Dr. George Ader, Artrite research director, says the materials look like ceramics, can be molded like phenolic plastics (thermosetting materials) and one type shows a tensile strength as high as 23,500 psi at 1300 F.

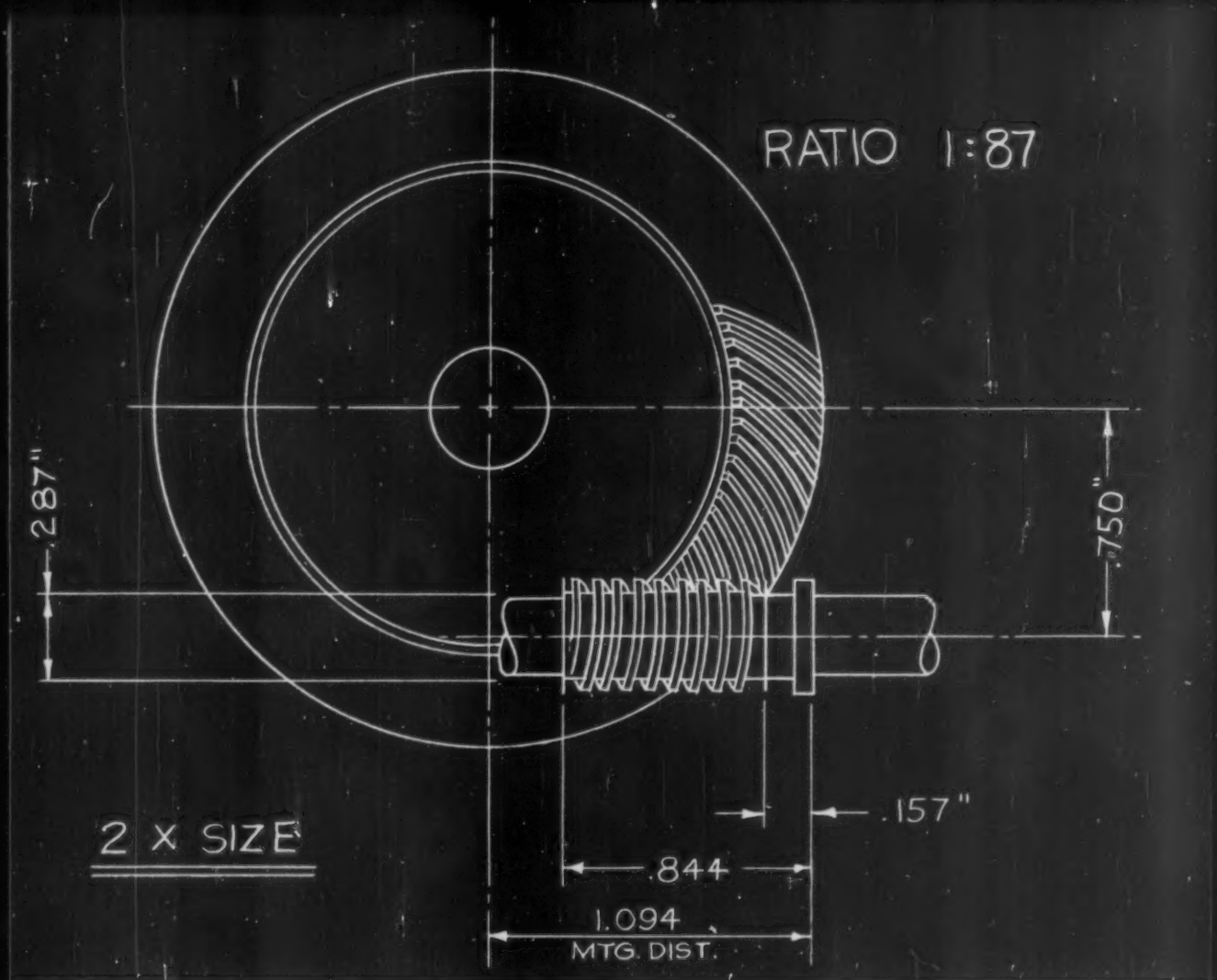
The materials are being developed under defense contract, and are not yet ready for commercial production. Says Ader, "We are still in the early research stages and a great deal of development work has yet to be done."

One-shot camera designed in Australia



BABY CAMERA is pictured with lens cover removed to show fuse insert. Device is assembled complete from just 40 parts (including all fasteners and the film disk itself).

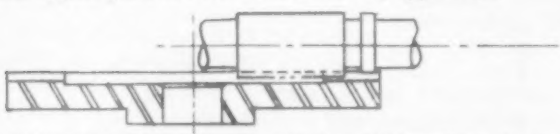
A fuse-operated, single-shot camera only 1½ in. dia and 1.2 in. long has been designed by the South Australia Weapons Research Establishment and is now going into production at Fairey Aviation. It uses disk-shaped film, takes its picture with a 0.3 millisec exposure at f.8, can be reloaded and reused after each firing. Only fuse and firing lever need be replaced. —ARG



HERE'S ANOTHER GEAR GLEASON BUILT FROM FIRST DESIGN TO FINAL PRODUCT

This is the finished prototype of a new high-ratio hypoid gear. Our customer will now produce it, royalty free, on his Gleason equipment.

This is but one example of what Gleason engineering service can do for people who need gears. Our facilities and advice are at your constant disposal for development of bevel and hypoid gears to meet the needs of any application.



This particular high-ratio pair (actual size shown in insert) offers several advantages over conventional gears:

GREATER STRENGTH. High-ratio hypoid pinions are larger and stronger than corresponding bevel pinions.

COMPACTNESS. Where space is a problem, the high-offset principle lets you design a more compact and flexible unit than the corresponding worm and wheel.

SMOOTHER ACTION. High-offset pairs provide smooth, quiet tooth action . . . *continuous* action even with only one or two teeth, because of the way the teeth wrap around the pinion.

STRADDLE MOUNTINGS. Cylindrical high-ratio pinions, with extended shank, make practical very rigid straddle mountings.

GRINDING. High reduction hypoids are cut on same Gleason equipment used on familiar bevel and hypoid gears. Same testers, quenchers and other auxiliary equipment can be used. Grinders are available for the ultimate in precision and finish to minimize friction.

LET GLEASON MAKE RECOMMENDATIONS. Send along a set of prints, and we'll be glad to study them and give you our thoughts on how best to make the gears you need.

GLEASON WORKS

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Magnetostrictive machine-tool drive designed in USSR

A microfeed drive developed at the Odessa Machine Design Bureau takes advantage of the magnetostriction effect (the tendency of some materials—notably, nickel—to expand and contract under influence of a magnetic field) to advance a cutting tool by small, precise increments.

The drive consists of a nickel rod centered in a magnetic coil. The rod is fixed to the machine-tool frame by two clamps, one at each end, so arranged that they will close independently in sequence. When one clamp is open, that end of the rod is free to move. If, then, the coil is energized, the rod will contract; and, when the current is turned off, the rod will lengthen towards the unclamped end, advancing the tool by a predetermined amount. The cycle can be repeated automatically, advancing the tool by the desired increment each time.

Cars getting nylon fuel systems

The all-plastic fuel system is still beyond the horizon; but the 1961 Imperial and 8-cyl Dodge cars will have nylon fuel-filter housings; and the 1962 models may have nylon gas lines as well, Spencer Chemical predicts. Easy to install, and requiring no special connectors, the lines are simply ¼-in. tubing, cut to size as needed. Fleet tests show they are durable, and should be adaptable to many types of gasoline-powered vehicles.

British offer new alloy-detector

An instrument that distinguishes among nonferrous alloys—aluminum, copper, and magnesium—on the basis of electrical conductivity has been designed in England. It's said to operate accurately even if the surface has been anodized or painted, or if the pickup head is not squarely on the surface. It will also indicate the degree of heat treatment the sample has received, say its designers, Townson & Mercer, Ltd, Beddington Lane, Croyden, Surrey.

The key element of the device, its sensing head, contains a coil which is, in effect, the primary winding of a low-frequency rf transformer, while the sample serves as a single, short-circuited turn that forms the secondary winding. As a result, the inductance of the primary coil and its losses are directly affected by the electrical characteristics of the sample under test. The sample reduces the inductance of the primary coil, so its tuned frequency rises; and increases the coil's loss, so its efficiency drops.

To measure these changes, the sensing head or primary coil is also part of an oscillatory tube circuit. The coil is in the grid, and the anode of this circuit is tuned to a slightly higher frequency than that of the coil. This arrangement helps to make the unit relatively insensitive to the distance between coil and sample.

As the frequency of the sensing coil—in the grid—increases, it tends to bring the anode and grid coils into line, and the grid-anode feedback increases until oscillation occurs; while a loss in grid-coil efficiency tends to retard this equalization process. It is by combining the two effects that circuit constants can be arranged to compensate for uneven location of the head, or the "distance" created by a layer of paint.

T & M is marketing the unit in Britain for about $110, with standards, batteries, and extra tubes available separately.

"Universal" lubricant coming up?

Can a lubricant be developed which will satisfy equally well the needs of heavy-duty gears for automotive rear axles, and the steel and bronze parts used in transmissions?

Some lubricant manufacturers claim such a lubricant is already available as a premium product. But users apparently are not entirely satisfied. They complain that additives often considered necessary for heavy-duty gear lubricants are frequently unnecessary, and even detrimental, for transmissions. For instance, R. E. Fletcher of Dana Corp says EP additives are not required for transmission gearing now in use and are discouraged because of their possible corrosive effect on bronze.

Judging from comments at the recent API and SAE meetings, the problem of a common lubricant is still far from solved. —ARG

WHAT'S HAPPENING IN RESEARCH . . .

Graphite combinations are stronger, more heat-resistant

Graphite "ceramics," containing titanium boride and molybdenum disilicide are about twice as strong—in both tension and compression—as standard graphite at room temperature, Boeing Aircraft reports. Furthermore, say Boeing engineers, these ceramics develop a self-healing protective coating when heated in air at temperatures above 2000 F. Compositions now under test contain about 50% graphite, with 25% of each of the other components.

Boeing emphasizes that data so far collected are not sufficient to guide structural design, but tests are continuing.

Data needed to predict acoustic fatigue life

Presently available tests are not adequate for predicting acoustic fatigue life, H. C. Schelderup of National Engineering Science Co told the ASTM. And the greatest need right now is for a body of reliable experimental data on which theoretical studies can be based. Random fatigue curves now in use are based on cumulative fatigue change and stress amplitude distributions that have not yet been fully proved. There is reason to believe, he says, that equations now in use tend to distort the probability density of high amplitudes and increase the probability of determinations indicating high stress.

New alloys for research

Metals melted in a shock tube and cooled at ultrahigh speed can be turned into highly unusual alloys, Dr Pol Duwez of Cal Tech reports. With a technique he calls "splat cooling," students working under his direction have produced, he says, the "first noncrystalline metal," an amorphous gold-silicon alloy; and several abnormal combinations of copper and silver and germanium and silver.

Owing to the nature of the technique, which involves shooting the molten metal against the inside of a refrigerated, spinning copper wheel, the alloys are produced only in the form of very thin foils. Duwez doubts that the technique can be adapted for anything like large-scale use, at least in the near future. However, it should provide a wealth of material for research, including new superconductive and magnetic alloys.

More on chemicals that affect metal strength

The effects of organic compounds on the strength of metals can be good as well as bad.

A report last year (*PE—Oct 12, '59, p 36*) from Columbia School of Mines indicated that wetting agents of the type used in lubricants could cut the strength of copper wire to a fifth of its normal value at high load, and double or triple initial creep rate.

Now, National Bureau of Standards reports other organic compounds have the opposite effect. Says NBS:

Coatings of long-chain polar substances (octyl and dodecyl alcohols and amines) greatly increase the fatigue strengths of steel, magnesium, and copper–beryllium alloys. On metal surfaces the polar compounds apparently form tightly packed monolayers that act as a barrier to water and oxygen molecules, with a strengthening effect that can range as high as 600%.

Water and nonpolar compounds like benzene and xylene, on the other hand, did seem to decrease fatigue life when they had any measurable effect at all.

NBS notes that neither type of compound had a beneficial effect on aluminum, titanium, and stainless steel—perhaps, NBS says, because of the tightly adherent oxide films that form on these materials.

A report on the NBS study is being prepared for publication.

briefs . . .

Silicon decreases corrosion resistance of cast iron rather than increases it, as has been thought, Fulmer Research Institute reports. In cases where resistance to corrosive wear was required, it has been the general practice to increase the silicon content toward the upper end of the 1 to 3% range normally used. However, the latest Fulmer studies indicate that 2 to 2½% silicon cast irons "have the least resistance to corrosion by acids. A reduction of the silicon content to about 1% can improve the corrosion resistance several fold."

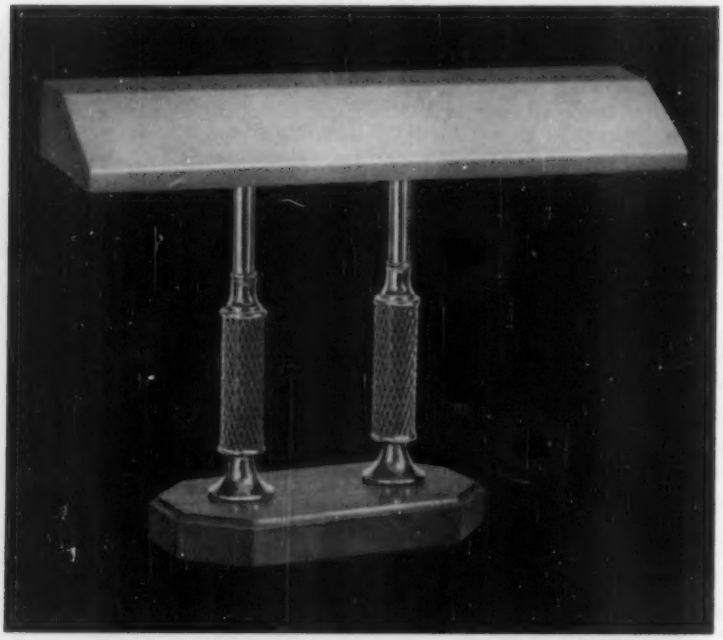
A report on the study may be obtained from FRI, Stoke Poges, Buckinghamshire, England.

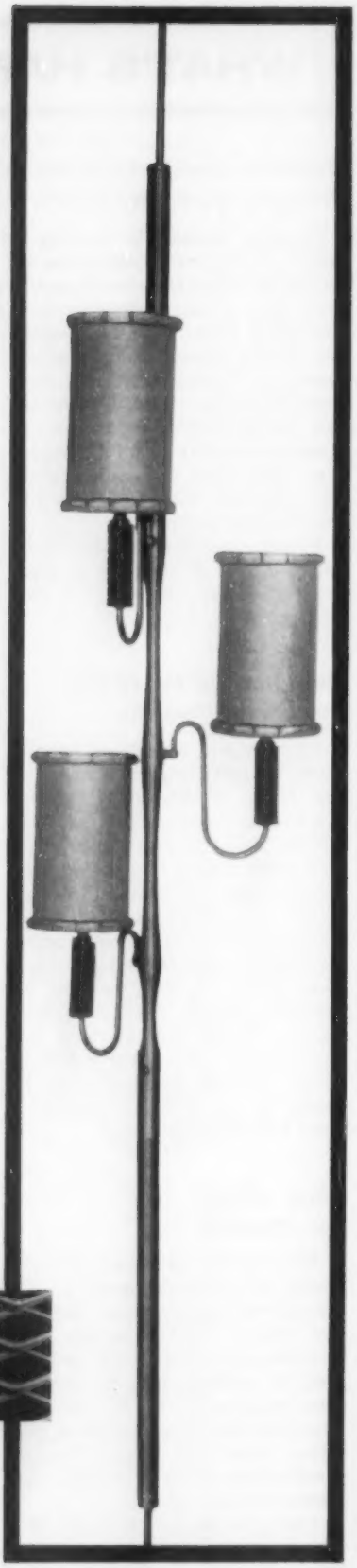
Another nuclear alloy is announced by Alcoa. Like the 80% columbium alloy being developed by DuPont (*PE—July 11, p 10*), this one is designed to resist the corrosive effects of high-temperature water and extend the permissible operating level above the present 450-F limit. The new Alcoa alloy, an improved version of its X8001 aluminum–nickel–iron composition, is said to be able to stand temperatures "to nearly 700 F."

Temperature-indicating paints that undergo multiple color changes at different temperature levels are being marketed by Air Reduction Sales Co as part of a full line of temperature-indicating paints and crayons that cover the range from 104 F to 2462 F. Airco says they can be used on all hot surfaces, and are unaffected by reducing atmospheres and most chemicals. Crayons are available in packages of 6 and 18. The paints come in 4-ounce and 1-lb cans.

Ductile chromium can be prepared by electrolytic methods, the Bureau of Mines reports; and, when nitrogen content is held to 20 ppm, the metal can be hot-worked to rod and sheet and drawn to wire that is ductile at room temperature. The process opens a direct route to production of high-purity material and paves the way for additional physical and mechanical studies. Tests of the wire, in the 50%-worked condition show ultimate tensile strengths in the 60,000 to 70,000-psi range, and elongations of 10 to 25%. A report (RI 5589) on the process, and on the tensile properties of wire produced this way may be obtained from the Bureau of Mines Publication Distribution Section. —ARG

"Filigrette" lamps manufactured by A. & P. Irmischer Co., Chicago, Ill.





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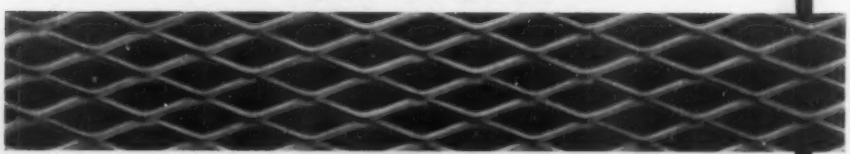

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FROM WASHINGTON . . .

Engineers set to vacate posts with new Administration

Top engineers and scientists holding key government positions will become vulnerable with a new Administration. Although these technical folk traditionally shun politics—to the point where most of them can't be definitely labeled as either Democrat or Republican—those of them who are appointed officials will submit their resignations when Eisenhower leaves the White House.

Some incumbents may be kept on by the new President, whether he be Democrat or Republican. But chances are that most of the men now holding office will be replaced, especially if the Democrats sweep into office.

Here are the top engineers and scientists who are political appointees:

• **George B. Kistiakowsky,** top scientific advisor to the President. Dr Kistiakowsky replaced James R. Killian. When Killian returned to MIT, Pres Eisenhower tapped Kistiakowsky from Harvard to fill the post. Both men have shunned publicity and acted strictly as advisor to the President.

• **T. Keith Glennan,** administrator of the National Aeronautics and Space Administration. Glennan was appointed from Case Institute to be the first director of the nation's space program.

• **Herbert F. York,** director of defense research and engineering. York has made a spectacular rise within the Pentagon since 1958 when he came to the Advanced Research Projects Agency.

There is some evidence that York will be kept, regardless of which party wins. He is considered one of the ablest men available for the post.

• **John B. Macauley,** deputy director of defense, research and engineering. He is one of the two civilian deputies for research and engineering; the other is **John H. Rubel,** deputy director of defense, research and engineering. Rubel was appointed to this position on April 1, 1960. Both men can be expected to leave at the end of Eisenhower's term.

The three Service assistant secretaries for research and development are: Courtland D. Perkins, Air Force; James H. Wakelin, Navy; and Richard S. Morse, Army. A new President will probably replace them with his own choices.

Post-election speedup of B-70 likely

A speedup in the Air Force's controversial B-70 bomber program can be expected after the elections, according to the latest predictions. Although Congress added $190 million to the $85 million the Administration approved for the project in this fiscal year, there are reports that Eisenhower is still cool to the idea of speeding up the program. He might very well impound the money until a new President is inaugurated.

A Democrat President would surely pump more money into the B-70, and insiders are guessing that a Republican would do the same.

Government engineers reap pay raises

Government-employed engineers and scientists have been handed a healthy 7½% pay raise. This will bolster government efforts to get and keep top engineering and scientific talent. The new pay hike was vetoed by Pres Eisenhower but overridden by Congress. It puts the starting salary up to around $6345 (GS-7) for the bulk of the engineers and scientists hired by the government.

Most of the thousands of such personnel employed by the government are lumped in the GS-12 and GS-13 brackets, now paying $10,255 to $11,935. Top positions pay more than $18,000 in super-grade categories.

After six months of corrosive glue . . .

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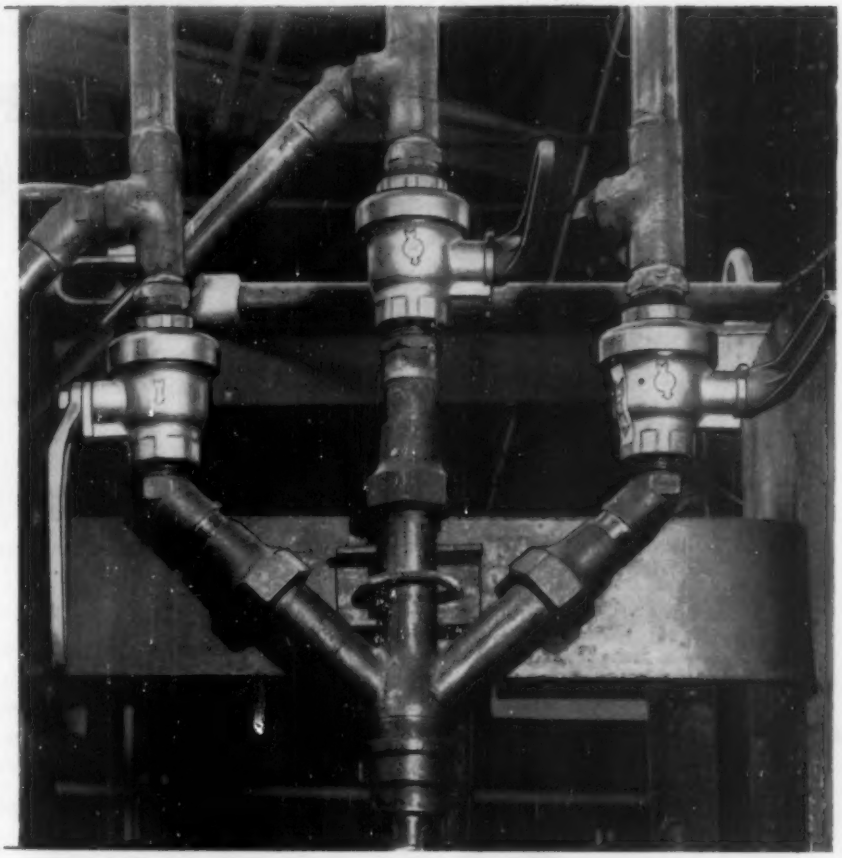

Controlling the flow of a highly corrosive paste base fluid requires a valve that can really take it. In the Calfskin Processing Division of the Endicott-Johnson Shoe Corporation, Rockwood Two-Seated Stainless Steel Ball Valves Fig. 204 are giving top performance under this severe condition.

These stainless steel valves provide maximum corrosion-resistance against this type of fluid, and despite its "solid" nature there is no build-up — thanks to full, round flow! What's more, shut off is *positive*, leakproof . . . because exclusive retainer springs back up two Teflon* seats . . . automatically compensate for pressure variations, wear, cold flow and temperature effects.

This leakproof, trouble-free service is typical of the way in which Rockwood Ball Valves handle everything — from alcohol to asphalt, air to water glass. *And* you get these other remarkable engineering features too: smooth, full, round flow; easy ¼ turn opening and closing; positive tight sealing without lubrication and longer wear resistance.

For use at temperatures from −100°F to 400°F, Rockwood Ball Valves can be easily modified for cryogenics applications. Available in all pipe sizes from ½″ to 10″, there are 4 models for service up to 600 p.s.i.

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*DuPont Reg. T.M. Teflon seals include seats and adjustable chevron stem packing. Also available with nylon or synthetic rubber seals.

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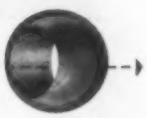

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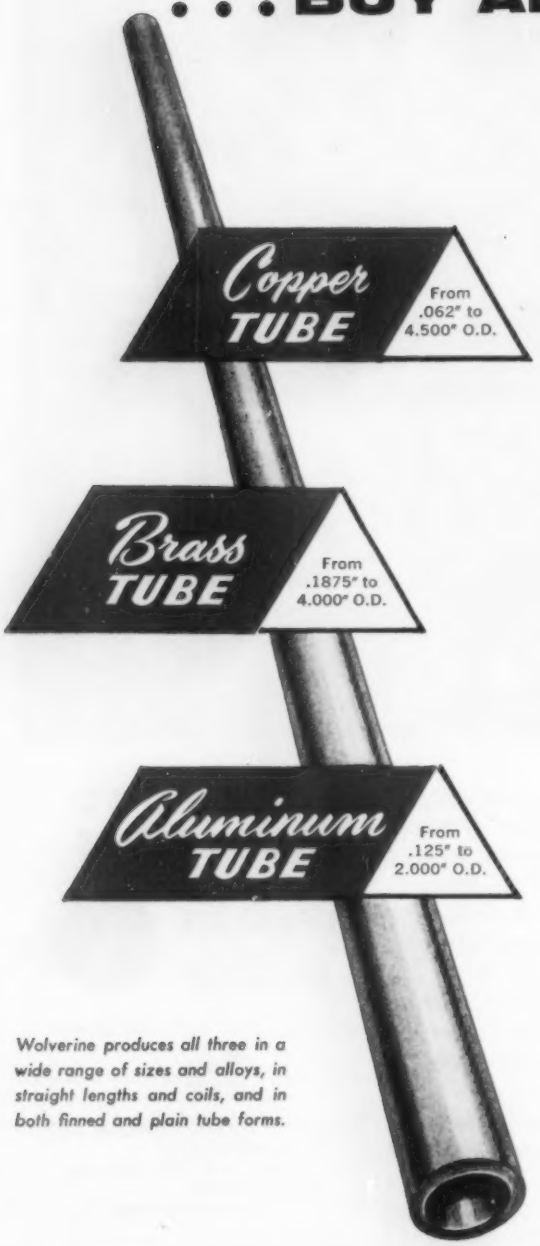

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Anticipating customer demands, and having the equipment, know-how and skilled employees needed to meet those demands, are all part of Wolverine's Tubemanship program. Wolverine customers can avail themselves of a wide range of specialized services in addition to various types of tubing.

Wolverine, for example, maintains complete fabrication facilities—is able to fin, spin, bend, coil—in short to do just about anything tubing customers require. From Wolverine's constant research program has come tubing specially designed to help solve the problems of such complex industries as refining, petro-chemical and petroleum processing, refrigeration and air conditioning—to name but a few.

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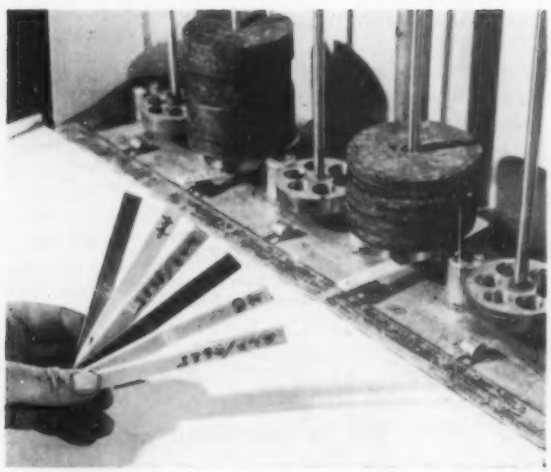


FLEXURAL CREEP-TESTING machine processes 15 specimens simultaneously while conventional equipment can handle only one specimen per test. At left, deflection measurements are being taken from a dial indicator while, at right, test specimens rest on rollers beneath a loading rod on which weights are placed. Boeing says the machine, which cost $3000 to develop, will shorten test programs on master plastic tools by more than 5 yr.

Creep-tester Holds 15 Specimens at a Time

SEATTLE—A new type of flexural creep-testing machine developed by Boeing Airplane Co. handles 15 test specimens simultaneouly under varying loads and at temperatures up to 200 F. Conventional equipment can handle only one specimen per test.

With the new machine, Boeing has been able to shorten a developmental test program on plastic master tools from 6 yr to 7 months. The problem arose in the development of epoxy-resin plastic tooling materials for master tools. Boeing wanted to be sure the tools would hold their tolerances while stored under the weight of other objects in a warehouse.

The new device consists of a rectangular metal case, about 6 ft long, which forms an enclosed temperature-controlled test chamber. Fifteen loading rods, onto which 1- and 5-lb lead weights are loaded for testing, are centered on test specimens over a sealed, water-filled base. Deflection measurements are made from a dial indicator that is moved along the top of the loading rods on a machined-steel channel. Slotted posts, set in the base, guide dowel pins protuding from each side of each loading rod. A gage records relative humidity. A thermostatically controlled heater circulates the water in the base and maintains the temperature of the test specimens within a range of 2 F.

From the tests, it was concluded that currently designed master tools will remain stable within the allowable tolerance when subjected to creep at normal operating loads and temperatures. Boeing engineers recommended that thickness of the solid, laminated master-tool face (gel coat to final ply) be established at ¼ in. and that all master tools should be reinforced, using a closed-box, plastics-face aluminum-honeycomb stiffener construction. ■

Patent Office Says the Lone Inventor Still Counts

ANN ARBOR—A recent study conducted by the US Dept of Commerce reveals that since 1940:

(1) Sixty percent of the nation's most important inventions came from independent persons or from small organizations

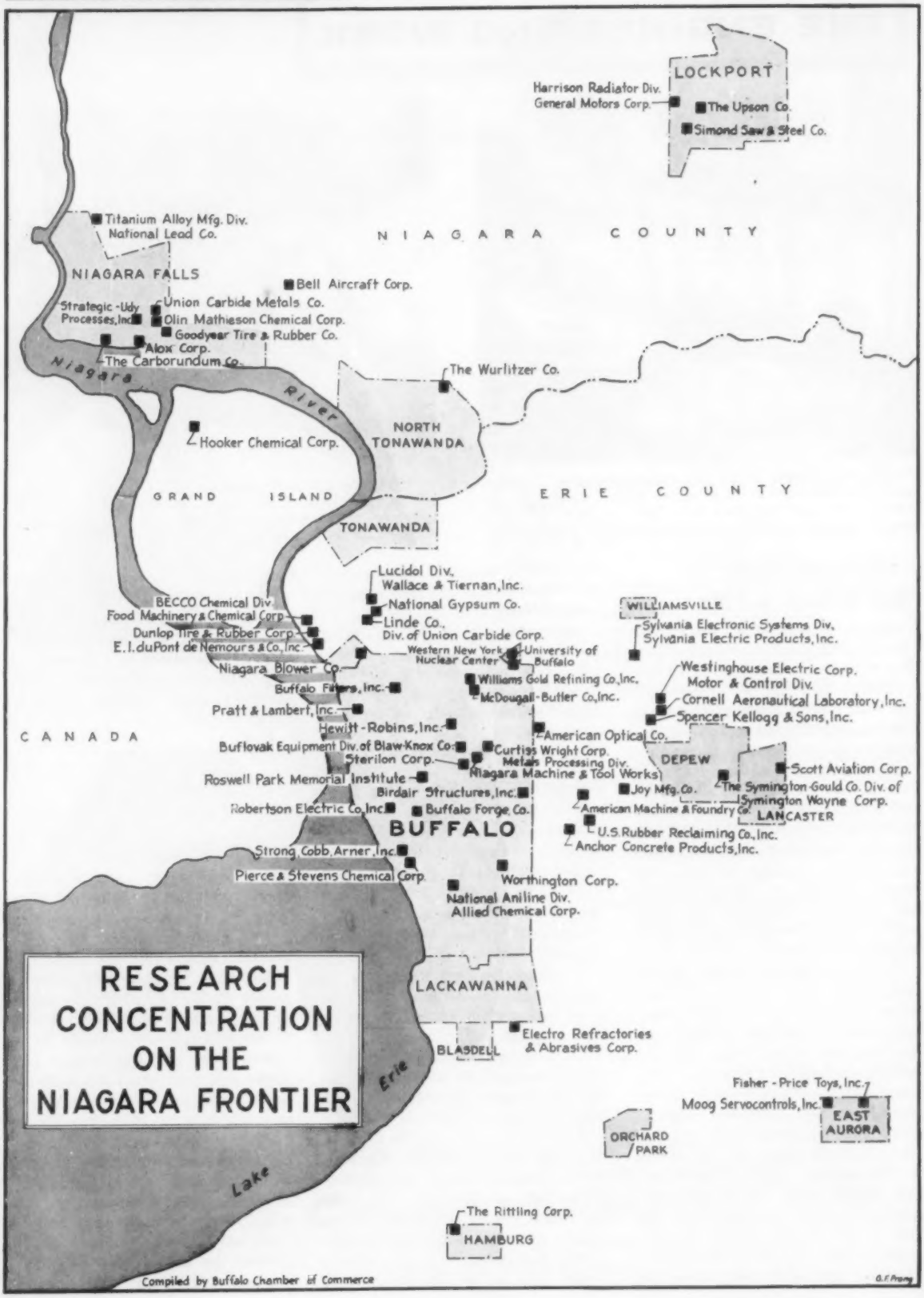
(2) About 40% of the patent applications filed in Washington DC are from independent or small-organization inventors, and

(3) Although the nation's R & D efforts increased by 12 times during the two decades, patent applications have risen only by one-sixth.

These facts, were cited by Maurice A. Crews, asst commissioner of patents for the Commerce Dept, speaking here at the Univ of Michigan. Crews said the Patent Office is exploring the possibility of establishing patent-search centers by classification. Such centers would help spread the word about inventions so that others could improve and build on them.

Libraries in 21 cities now have patent files but by number only. A researcher in one of these must look up the numbers of each of the patents and then retrieve them. When filed by classification, he need only go to the proper section to find all the patents on the subject he's investigating. Patent searching not only tells the inventor if he has a patentable idea, Crews said, but "often stimulates the engineer or inventor, even when his own idea turns out not to be original."

Also, to help engineers, chemists, executives and inventors to keep up with new ideas, the weekly *Patent Office Gazette* "is arranged in such a way that the reader will need to refer only to two or three pages to identify the newly issued patents he wants to read," Crews added. ■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Research—Key to Industrial and Area Growth

BUFFALO—The hallmark of the Niagara Frontier is the world's most popular waterfall. But the tourist who visits Niagara Falls today sees an awesome backdrop to the natural beauty—a complex of cracking towers, power lines and industrial structures. For the water resources of this area have long had as much industrial as esthetic appeal—in early days as a highway linking the East with sources of raw materials and markets in the interior; and later as a source of inexpensive electric power.

With the opening of the St Lawrence Seaway and the promise of additional hydroelectric power facilities, the Niagara Frontier is becoming even more attractive to industry. More companies are coming in, and industry will increasingly dominate the area. The new companies are placing increased emphasis on research and engineering and the older companies are continuing to expand their R & D facilities. This area today boasts one of the heaviest concentrations of R & D facilities in the nation (see map).

Today, the Niagara Frontier—Niagara and Erie Counties and the cities of Niagara Falls, Buffalo, and Tonawanda—ranks eighth in the nation in its investments for research. Its growth in research and manufacturing will come partly from the universities and private research groups in the forefront of basic breakthroughs in engineering; from the vast research and engineering laboratories developing the new products that represent the manufacturing dollar volume of tomorrow; and from the new industries that have been developed in the area and are now beginning to feel their way into research.

REACTOR FOR THE AREA

With a research budget exceeding $2½ million, the Univ of Buffalo ranks among the top five research organizations in the Niagara Frontier. And with the completion next year of its nuclear research facility, its research budget should continue to grow.

A large percentage—about 75%—is in medical research; however, physics, chemistry, engineering, are represented. This university is justly proud in having one of the major facilities for the study and investigation of the properties of carbon. Some $150,000 a year is going into the study of the mechanical and electronic properties of carbon at high temperatures—above 6000 F—with sponsors ranging from the federal government through state government to National Science Foundation and National Carbon Co.

The chemistry department is investigating for the Armed Forces the effect of low temperatures on synthetic rubbers and at the same time attempting to find an organic stable liquid polymer at red heat.

But probably most interesting on the Univ of Buffalo campus is the Western New York Nuclear Research Center nearing completion. This truly cooperative project embraces local industry and the state and federal governments. University administrators, knowing the need for radiation in medicine, undertook a study to determine the needs of local industry for a nuclear center. They were heartened by outright gifts from several local firms to the tune of $375,000. With this as a base, $1.7 million came from state and federal agencies.

The building and its swimming-pool reactor should be ready by early 1961; its projected initial research budget is $100,000. Sponsoring companies and others in the area requiring radioactive materials will be served here at low cost.

GRAND ISLAND RESEARCH CENTER

Central research for the four divisions of Hooker Chemical Corp is in a new $3.6-million building on Grand Island—about midway between Niagara Falls and Buffalo. Here nearly 200 people work on chemical and plastics research, almost all of it basic.

A major portion of Hooker's basic research in plastics is investigating why and how materials burn. Object is to find better flameproofing chemicals that can be mixed with paper, cloth, plastics to make them fireproof; Hooker has been highly successful, for example, in the plastics field, with Hetrofoam. These are a series of polyurethane foams with fire-retardant properties built into the polymer molecule.

In addition to such planned research, researchers can spend some 10% of their time investigating areas of particular interest to them. From this, Hooker expects some major discoveries that will further enhance their part of the chemical and plastics markets.

Sales of new products have doubled in each of the past three years. About seven new products will reach market development this year; 22 went to divisional sales departments last year.

The $4-million research budget splits about 55-45 between chemicals and plastics, and manpower splits about 60-40 the same way. Hooker looks for about a 24-man increase in its research center this year and, with its low turnover-rate and high acceptance since completion of its new laboratory, expects an even faster industrial growth from newly developed products.

INTERNAL RESEARCH ADDS TO GROWTH

A thousand engineers and technicians; 175 projects in work; $15 million in contracts. This tells the story of Cornell Aeronautical Laboratory, which didn't exist 14 years ago. CAL sticks to aeronautics and related fields, and in the words of its president, Ira G. Ross, "seek out, aggressively sells, and explores concepts unprofitable today but needed tomorrow." Many of the projects developed through its internal-research budget are bearing fruit today—among them, a hypersonic tunnel, terrain-avoidance system, and automobile stability and control.

About $300,000 annually is now being devoted to internal research. Under this program, individual scientists and engineers are encouraged to investigate pertinent areas of interest which are not funded by outside sponsors. A case in point is the wave superheater hypersonic tunnel now being built at a cost of $3.1 million and to be ready for use by mid-1961.

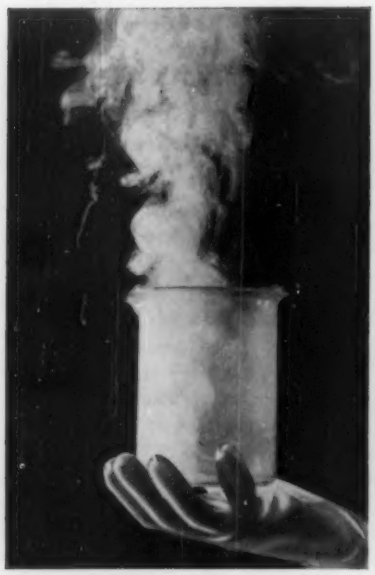
Design and development of a device capable of producing a continuous hypersonic stream of high-temperature (9000 F) air for periods of 15 to 20 sec was started in 1950 when a CAL engineer conceived the idea of a hypersonic shock tunnel. Internal funds supported initial research until the idea was proved and a sponsor found—in this case, the Air Force with funds provided by the Air Research Projects Agency.

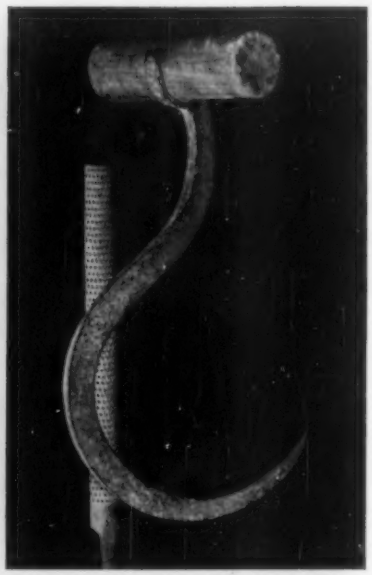
How does a research organization

continued on page 20

ENJAY BUTYL

IS TOPS IN ALL-'ROUND





RESISTANCE TO TEAR AND ABRASION

Enjay Butyl offers the highest aged tear strength of any rubber . . . even after long exposure to ozone and heat! Its inherent toughness resists abrasive wear, in such applications as tires, conveyer belts, hose and other mechanical goods.

RESISTANCE TO SUN-LIGHT AND WEATHERING

Enjay Butyl has proven its resistance to ultra-violet light, ozone, oxidation, moisture and mildew. Increases life of products such as weatherstrips, garden hose, wading pools and automotive parts.

RESISTANCE TO CHEMICALS

Enjay Butyl, because of its unique and extremely low degree of unsaturation, offers excellent resistance to corrosive chemicals. The preferred rubber for tank linings, hose, seals, gaskets and other applications where exacting chemical resistance is required.

VIVID COLORS

Enjay Butyl requires no additives for quality coloring over a wide range of hues. Famous for colorability and smooth finishes, Butyl has been successfully plastic coated for special applications.

RUBBER
PERFORMANCE

DAMPING PROPERTIES

Enjay Butyl absorbs shock and vibrational energy more completely than any other rubber. Resiliency can be varied in compounding and processing. Butyl is ideal for axle and body bumpers, motor mounts and sound-deadening applications.

IMPERMEABILITY TO GASES AND MOISTURE

Enjay Butyl is tops in impermeability to gases and moisture . . . retains air pressure 8 times better than natural rubber. Outperforms other rubbers in such application as inner tubes, jar and bottle seals, hoses and inflatable goods.

ELECTRICAL RESISTANCE

Enjay Butyl tops all vulcanizable rubbers in electrical and dielectric properties . . . in resistance to corona and ozone breakdown and water absorption. Its high dielectric strength insures against electric breakdown under normal or surge voltage. Its heat resistance permits higher current flow for a given conductor size.

The outstanding properties of Butyl Rubber create new horizons for the designer, and offer to manufacturers an opportunity to utilize the qualities of rubber in applications never before possible. The unique properties of Butyl have led to vast improvement in many existing products. Technical skills will open the way to countless new uses.

Butyl is the "idea" rubber with uses stretching as far as the imagination can reach. We'll be glad to tell you all about it. Just contact the nearest Enjay office.

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CIRCLE 19 ON READER SERVICE CARD

continued from page 17

such as this sponsor industrial growth? Two Frontier companies, employing some 1000 employees and with sales of many millions of dollars, received their start at CAL. One is a recent company started by ex-CAL engineer Walter Bird—it's in the business of inflatable rubber buildings. These are being extensively used in the Arctic region for radomes, campsites, and similar purposes.

MOOG GROWS AND EXPANDS

The other CAL "graduate" is Moog Servocontrol Inc, formed less than 10 years ago, based on a servovalve designed by William Moog while he was at CAL. With no manufacturer expressing interest in the new design, Moog, with the blessing of CAL, set up facilities in his garage to supply demands from the missile industry. Today, the company does a $10-million business.

This young company is just now entering a period of organized research. Previously, research led to design improvements on the initial servovalve—four major modifications in 10 years. An industrial-products division has been formed and although its initial product is the Moog valve it has been repackaged for industrial use. But more important are the long-range plans of the organization. Moog sees three areas of growth and these are being actively explored:

Design and manufacture of a series of components for electrohydraulic systems. These would be purchased and used by a manufacturer.

Design and manufacture of complete control systems on a contract basis for a manufacturer.

Design of a complete proprietary system to do a particular job.

Some 50 technical men are presently engaged in refining the company's products or doing research to improve the company's position in the valve business. Ultimate goal is to reduce the 95%-5% military-to-civilian market to a 50-50 split.

OTHERS ADD TO GROWTH

These four examples point up some of the advances being made in industrial and area growth in the Niagara Frontier. Many other companies are engaged in research. For example:

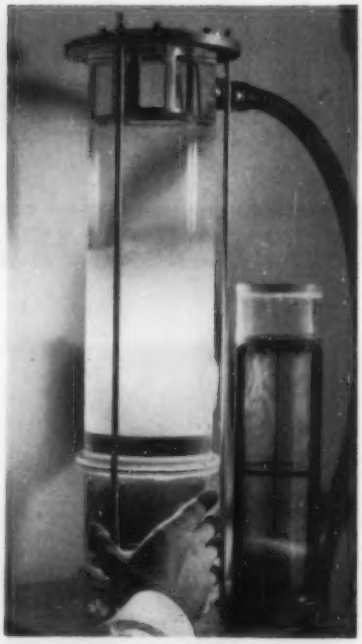
National Gypsum Co states it was manufacturing 20 products in the last half of 1958 which were not available at the beginning of the year.

Under a single roof, Westinghouse Motor and Control Div plant in Cheektowaga has facilities and engineers to conduct effective research and manufacturing of a wide range of electrical products.

Linde Co, Div of Union Carbide Corp, is investigating the whole new technology of cryogenics along with its many other research projects in the low-temperature field. Other Union low-temperature field.

Also important to the growth of the area are the research facilities of Worthington, Sylvania, Bell Aircraft, Allied Chemical Corp's National Aniline Div, Carborundum, Du Pont and Spencer Kellogg.

A totally different kind of research program—but equally important to the industrial and area growth—is being carried on by Niagara Mohawk Power Corp. Through its Area Development Department, the power company conducts a continuing program of economic research on the community itself. The data and information on industrial facilities is sponsored to insure a continued sound economical growth of the communities it serves.



SOLID-WALL WATER-FLUIDIZED, nuclear reactor model being studied at Cornell Lab is one of the many internally sponsored programs. Here, fluid flow performance of solid- and porous-wall reactor is being compared. Other internal projects include thermal expansion of ceramics, new communcation techniques, silicon carbide fibers and others.

FLAMEPROOFING CHEMICALS stop burning of a rigid polyurethane foam. Foams made of Hooker's Hetrofoam do not support combustion. When chemically activated, these alkyd resins foam and set, forming a rigid foam structure of preselected density to give exceptional insulating and electronic values.

Educators Told to Separate Science and Engineering

LAFAYETTE, IND—The dangers inherent in blurring the educational distinctions between engineering and science came up for sharp comment at this year's annual meeting of the American Society for Engineering Education.

"The functions of engineering and science are quite different and the training for them ought to be different if each is to carry on its role in the optimum way," Dr L. V. Berkner, President of Associated Universities Inc, warned the group.

Last year, Berkner said, our universities graduated fewer than a thousand students with doctorates in engineering. Most engineers who now hold doctorates first got their degrees in science, then switched into engineering. This approach burdens engineers with much training that is useless to them, though essential to scientists. And it fails to give the engineer knowledge about materials, processes, reliability and other engineering considerations that are necessary to convert scientific ideas to useful products.

Dr Berkner said that the bachelor's degree should emphasize physics, chemistry, mathematics, and the engineering problems that derive from these sciences. With engineering problem-solving extended across the entire field of technology, students grasp the magnitude and applicability of engineering principles. Specialization in a particular branch of engineering—chemical, mechanical, etc.—should come with the advanced degree.

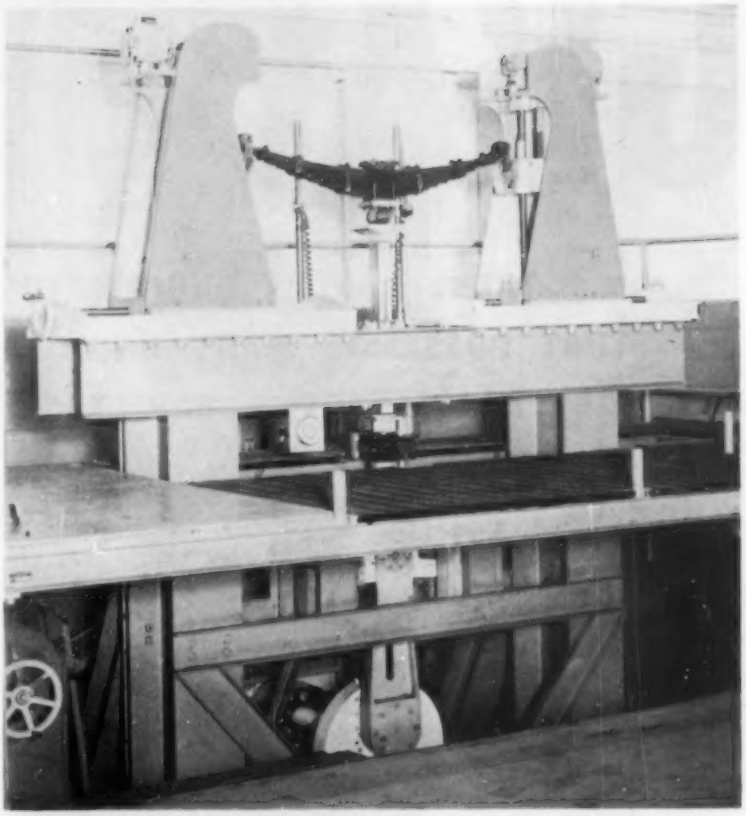
At the doctorate level, Berkner continued, the role of research becomes important. Research should be viewed as an opportunity for students to do creative and significant work, not as an opportunity for professors to obtain "cheap, captive and intelligent manpower," as is often the case today. Dr Berkner urged creation of regional centers for providing research equipment that is too expensive for individual schools but necessary for study of materials and other engineering problems.

"The greatest problem in engineering education," Theodore von Karman, founder of Aerojet-General Corp, told the ASEE, "is to find a way to teach fundamentals of natural sciences, especially physics and chemistry, and how to apply these to create new designs—all without increasing the number of years in school."

Today, industry provides a sort of apprenticeship period during which the engineers learn how to make practical application of their college-learned theory. Engineering schools should teach this to their students. Only if the schools solve this problem will the trend of students away from engineering toward science be stemmed.

Dr Frederick L. Hovde, president of Purdue Univ, called for one course in the freshman or sophomore curriculum that will require a completely personal and individual effort belonging to the doer, not measured by classroom competition. Such a course would face the students with the most difficult of all problems—self-direction, planning and doing on his own. ■

Measures Spring Fatigue



Designed and built by Battelle Memorial Institute, this machine tests heavy truck springs in fatigue. Rated capacity is 12,000 lb. Machine is equipped with a load-sensing and cut-off mechanism that can measure loads either statically or dynamically, then stop at any predetermined load-loss level.

ARPA Spends for Materials Research

ITHACA NY—Basic research in the science of materials will be greatly expanded soon at three leading US universities by the Advanced Research Projects Agency (ARPA) of the Defense Dept.

The multimillion-dollar program calls for signing long-term contracts with Cornell Univ, Northwestern Univ and the Univ of Pennsylvania, and will provide interdisciplinary research and graduate-student training in materials.

According to ARPA officials, Cornell will receive $6.1 million during the first four years of the contract. With some of this money, the school will build a Materials Science Center building from which it will administer the ARPA contract. It will expand its training of PhD experts in materials.

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POINTS OF VIEW

THE QUESTION:

Is Today's Engineering

Ray Borst is a young man with a gripe. After working with several industrial companies, he feels that management has failed to waken to the necessity for creativity. But, Borst says, the trouble begins in our universities.

We teach engineering today by the same method that read'n, 'rit'n and 'rithmetic were taught 30 or 40 years ago—pure brute repetition. Yet the first condition necessary for creative thought is an unrestricted mind, the ability to conceive numerous possible solutions. How can a mind that has been fed on repetition do this? Moreover, our so-called "best students" are given the better grades for their ability to do dull repetitious calculations. This mistake is further perpetuated because it is these students with the better grades that go on to graduate school. Hence, the products of our graduate schools are not the creative individuals that we need. Instead, our universities reject the impatient, the enthusiastic, the ambitious individual.

However, creativity can't be taught to the uncreative masses of common people. Why couldn't half a dozen universities offer a low-tuition opportunity for these individuals to gather and study together? The only approach to this problem that has been demonstrated is the University of Michigan's design program—one year beyond MS for those not wanting to do PhD research. As for curriculum, all that we now know about creativity wouldn't make one good college course. Rather, the present basic courses—more of them over a broader base—should be taught, not to produce an answer by a step-by-step procedure, but to teach an approach to the problem and to search for a multiplicity of solutions. Also, this new system would center around design courses—training creative engineers to be receptive to new approaches and solutions.

Since we measure creativity by results, I wonder if

Holding a BSME and a BSAE from the Univ of West Virginia, Ray Borst's first job was with the ITE Circuit Breaker Co and his next with the Product Research Div of the Budd Co. He says, "Four months later (and my total work assignment consisting of three single-line graphs over this period) I quit to enroll in graduate school at Wisconsin. Here I expect to receive a MSME sometime next year. I believe, and in direct opposition to some of my professors, that the creative individual must have a broad background. From this he associates rather wide and seemingly unrelated ideas, then rearranges them into new solutions. With this in mind you can understand why I want to take courses in mechanical engineering, engineering mechanics, metallurgy and mathematics."

Education Giving Us Creative Engineers?

we are talking about the right group when we speak of "creative engineers." Successful engineering projects are successful because an interested individual sees them through. It does not necessarily hold true that this system is the best or the most fruitful, but it is the easiest to administer and, for this reason, the most popular. Might it not be more accurate to count the number of ideas? The prolific creative individual will have many projects kicking around in his head at the same time. I doubt that an outstanding creative individual can work on one subject for an extended period of time. Yet we reject this type of person who, with some assistance, could provide many more ideas than the "ideal" innovator.

I question whether industry wants a truly creative individual. J. F. Young of the Appliance and Merchandise Dept, General Electric Co, in his paper, "Developing Creative Engineers" (ASME pamphlet, *Creative Engineering*), discusses this point. General Electric set up a program to try and develop creative inventive ability in young engineers. Young summarizes their experience: "The graduates have been of two types. A small portion have possessed a very high degree of inventiveness and have been interested only in developmental phases of engineering. They thrive on new problems but have little interest in carrying through to a finished product once the method of accomplishing the result is known and proved. A second (majority) type follows the objective of the program more closely." This last statement leads me to conclude that GE and other industries do not want creative individuals. They apparently want people who can plod along at a slow, narrow-minded pace giving us crackthroughs rather than breakthroughs.

Dr Finn J. Larsen of Minneapolis-Honeywell says in the article, "Are We Content with a 'Crackthrough'?" (*PE—Mar 28, p 66*) ". . . we do have a group of staff engineers who are assigned to explore the unknown in engineering. . ." Staff engineers are traditionally the older engineers. But the creative individual is the young lad who doesn't know why it won't work, doesn't want to know why it won't, because he is going to make it work. William D. McGuigan of Stanford Research Institute in the same article (p 65) says, "Industry wants competence, not creativity. . ." They want the educated salesmen that our colleges and universities are turning out in huge quantities. Industry errs in that the supervising engineer and management decide what projects will be worked on. Put a 25- or 30-year-old dreamer in charge of a Research and Development department, no PhD either, and he will give you products that you never conceived possible. This is where conservatism is stifling creativity. It is not on the part of the innovator, it is the fault of management.

What we need is a conference of young people—none of them over 35 or 40—the present ripening crop of innovators. Let these individuals specify the conditions that are needed. They are your creative people; they are the ones who are subjected to the environment. They will deliver your Breakthrough.

Further, I question whether we can be sure that researchers are necessarily creative. Anyone with a little education, or perhaps even better, a little experience, can run countless tests, add up the data and write the thesis necessary to obtain an advanced degree. It is reasonable to assume that no small portion of the people in research work like their jobs. Psychologists have known for years that happiness is a function of the mental capacity of the individual and the amount of thought required by the job. The truly happy individual is the person whose job requires just about as much mental ability as he is actually endowed with. I wonder then if a brilliant person can endure the dull repetitious work involved with research for any extended period of time?

Elmer Tangerman says in his article, "Creativity" (*PE—Aug 24 '59, p 20*), that a study showed ". . . creative people . . . the architects, writers, and painters were most commonly without degrees." I'll wager that, if you omit quasi-creative researchers, the creative engineer must be included with, and will undoubtedly head the class of, these degreeless creative individuals. Take 50 dreamers and a staff of technicians to support them, and this group will make advances that will make the Russians appear to be moving backwards. They will give you more than Breakthroughs, they will give you Smashthroughs.

HERCULES

Plastics Hi-Lites

Vol. II, No. 3

New Housing Projects, 1960 Style

Product builders achieve significant improvements with Pro-fax® polypropylene

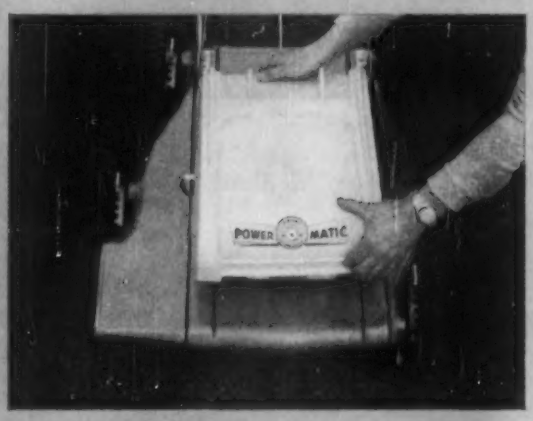
BULLETIN

WASHINGTON, D. C. . . . The Food & Drug Administration has issued a formal regulation, appearing in the Federal Register, authorizing the use of Pro-fax polypropylene in products coming in direct contact with all kinds of food. Pro-fax thus becomes the first packaging material to win approval through the issuance of a formal Food Additives regulation. Author of the successful petition was Hercules Powder Company. Hercules predicts widespread use of Pro-fax in food uses, including packaging films, molded containers, coatings, liners and dispensers used in food handling.

Plastic housings in all manner of sizes and shapes, used in an across-the-board list of products, are among the first big developments of the '60s . . . an exciting clue to things ahead. Materials such as Pro-fax polypropylene are fast changing the face and function of many a product, lending new color and styling appeal, improved performance, and above all—*lower cost!*

Measured by yesterday's standards the achievements of today's new materials border on the impossible: they provide high resistance to heat, moisture, household chemicals, foods and cosmetics. They offer rich color and are ideally adapted to the attractive styling requisite for modern merchandising. Yet because they are low-cost materials, adaptable to rapid cycle injection-molding, they are *priced right!*

No wonder that just about every new plastic housing project you see these days is a Pro-fax project. Here are a few of the latest.



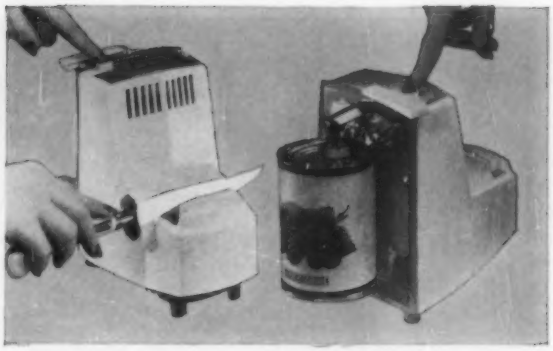
AROUND THE YARD

A handsome Pro-fax housing is the new symbol of quality on today's modern power mower. An excellent example is this high-styled motor shroud for the 1960 Power-Matic. Its beauty belies its rugged strength, for this sturdy housing is virtually unbreakable and will permanently resist heat, moisture, gasoline, oils and greases. Molded-in mountings eliminate the need for metal parts in the assembly, providing a design that is completely corrosion-proof. In addition to the Power-Matic shroud, Amos Molded Plastics, Edinburg, Indiana, has designed, developed and produced a series of similarly well-engineered Pro-fax mower housings for Power Equipment, Cicero, Indiana, and its value-conscious customers.

IN THE KITCHEN

Pro-fax in the kitchen spells new convenience and satisfaction for homemakers. Knapp-Monarch's Redi-Matic automatic can opener-knife sharpener features a gleaming white Pro-fax housing, and as a result is impervious to damage from staining and rough handling. The Redi-Matic automatically opens cans of all shapes, and sharpens knives of all sizes. Thanks to Pro-fax, it's a luxury styled unit designed to blend beautifully with any kitchen decor.

Molded by: Warren Molded Plastics, Cortland, Ohio.



ABOUT THE HOUSE

Fast becoming standard home accessories, vaporizers and humidifiers have gotten a big boost in appearance and function by the use of Pro-fax. The new Northern automatic vaporizer/humidifier (shown here) features a bowl and lid molded with Pro-fax, in contrasting colors, which combine in a compact, easy-to-carry appliance that is both useful and attractive wherever it serves in the house.

Pro-fax bowl and lid molded by Cruver Manufacturing Company, Chicago, Illinois.

IN THE NURSERY

Modern style and top performance go hand in hand in Formulette's bottle warmer. It's molded with Pro-fax, of course, for a luxury finish plus resistance to heat and moisture, in a rigid, thin-walled, lightweight unit that is easy to handle, always safe and the ultimate in completely sanitary nursery equipment.

Molded by Boonton Molding Company, Boonton, New Jersey, for Formulette Company, Inc., Jamaica, New York.

IN THE LUNCH BOX

Breadwinners, too, enjoy the convenience and luxury of Pro-fax. The handle, jacket, and collar of Aladdin's new Dura-Clad vacuum bottle, with its unique "Pitcher-Pour" handle, are all molded in one piece with Pro-fax. Pint-size (shown here in use) fits all workmen's lunch kits while the quart size (appearing in the background) is designed to fit conventional outing kits. Both models are heat-, scratch-, and stain-proof.

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CP60-9 THREE NEW MATERIALS FOR THE PLASTIC INDUSTRY

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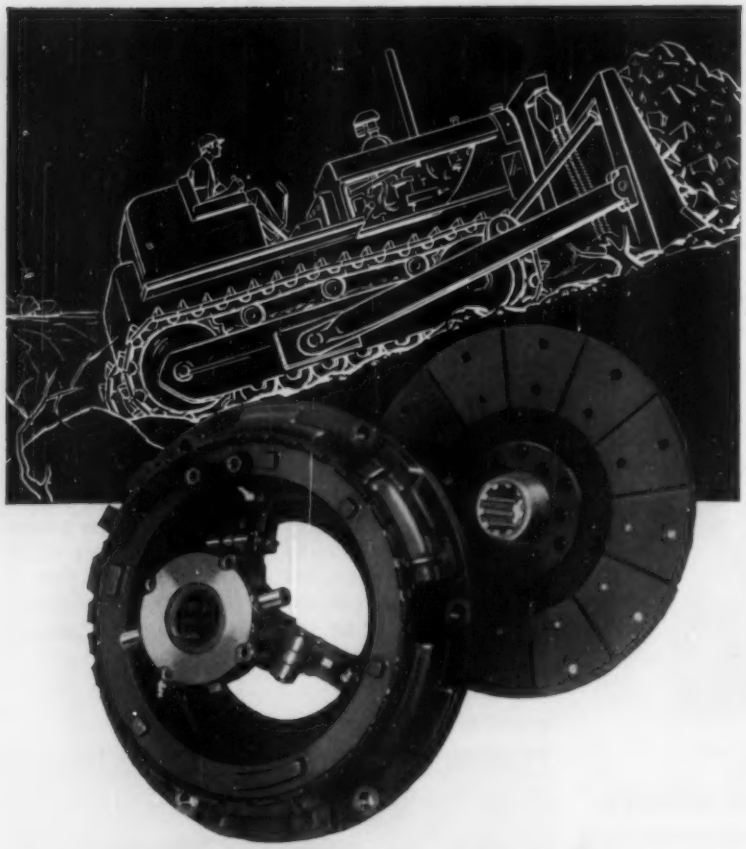

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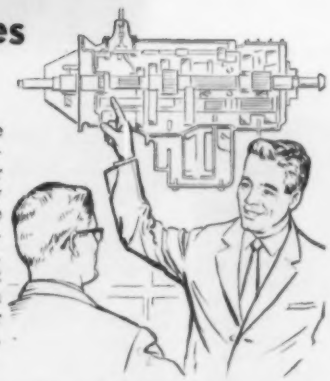

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READER TO EDITOR

Patent Searchers

To the Editor:

I read "Patent Subclasses a Rich Vein of Free Ideas" (June 6, p 83) with much interest. I agree with the usefulness of the Patent Office to the designer. However, I never have had any particular difficulty in using the patent system. My standard method in starting a really new design, (a not-too-frequent matter) is to first have a patent search made in Washington. Only then, after a careful examination of the patents, do I put pencil to paper. I may have one or more additional searches made as the design proceeds. This costs money but is well worth it for guidance and insurance against wasting time. Incidentally, it also helps a company's patent attorney when the time comes to prepare one's own case.

I don't think the change suggested would greatly help the designer. He would not be a good patent-searcher in any case without training and experience, any more than a good law library would make an engineer a good lawyer.

—Alan Osbourne
Cabin John, Md

Fuller Dogmatism

To the Editor:

We received your June 20 issue of Product Engineering and read your staff interview with R. Buckminster Fuller. The last paragraph is filled with both truth and error and is offered in typical Fuller dogmatism. Industrial designers do not all agree with the making of superficial changes and the "planned obsolescence" theory. I would say that the greater number of the nationally recognized offices do not believe in this theory. The industrial designer of today is not just a packager. He is the architect of product design. He understands materials, techniques and costs of manufacture, and he has a broad knowledge of marketing. Furthermore, if his work is to find general consumer acceptance, he must understand the psychology of buying. To say that a man is doomed when he becomes an industrial designer is just plain nonsense.

Even assuming that the designer does nothing but style things that are already functionally good—is not this an asset? What price ugliness? Have not the interiors of our homes and offices been made more pleasant because of style? The practice of styling is not bad basically—it is simply limiting, and that is all.

—Joseph Palma Jr
Palma & Knapp Assoc
River Forest, Ill

To the Editor:

With reference to your article on R. Buckminster Fuller (June 20, p 24), as short as it was I'm inclined to agree with the statement made by Frank Lloyd Wright. I've heard of this man Fuller off and on during my lifetime and I like his thinking.

It's a sad commentary on our way of

life, however, that a man with such talents is unable to benefit mankind to his fullest capacity. His Dymaxion-car project is a fantastic example of the type of thinking that must predominate in the minds of many investors. If the automotive interests would have backed such a project in 1932 and advertised it as well as they do their present products, we would probably be driving air cars or some other improved device by now. Instead, I'll predict that the Dymaxion car (or one similar to it) will be on the market within five years; and to top it off, it will probably be hailed as the most advanced design of the century. Actually, we're thirty years behind the times.

To digress but a moment, I have often wondered what would happen if people like Fuller were to receive the backing of people like Peron (who is said to be worth around $700 million). Such an amalgamation, while rare, would no doubt result in tremendous benefits to mankind. Instead, Peron and others like him, are prone to using their funds to create unrest in the world; while Fuller and others like him struggle to sell their ideas for improving conditions in the world. It is indeed a sad and unfortunate situation.

—Richard Paulson
La Jolla, Calif

American Products Not Maintainable

To the Editor:

Congratulations for a good and overdue editorial on maintainability (May 30, p 41). Based on my 6½ years abroad, may I add that we have lost or are losing most of our foreign market because our otherwise superior American products simply are not maintainable. You cited why.

—J H Caddess
Assoc Prof of ME
A & M College of Texas

COMING EVENTS

AUGUST

1-3 . . . . Institute of Radio Engineers, 4th Global Communications Symposium. Statler-Hilton Hotel, Washington, DC

28-Sep 1 . . . . American Society of Mechanical Engineers, International Heat Transfer Conference, University of Colorado, Boulder, Colo

SEPTEMBER

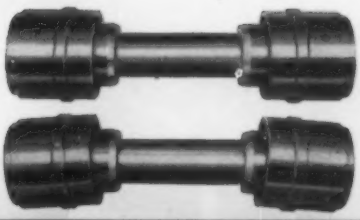
6-16 . . . . National Machine Tool Builders Association, Production Engineering Show, International Amphitheater, Chicago

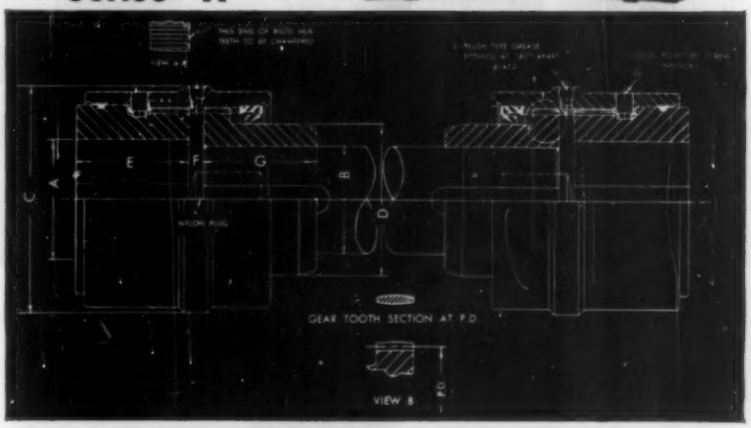
7-9 . . . . American Society of Mechanical Engineers jointly with AIChE, AIEE, IRE, and ISA; Joint Automatic Control Conference, Massachusetts Institute of Technology, Cambridge, Mass

26-28 . . . . Standards Engineers Society, 9th Annual Meeting, Hilton Hotel, Pittsburgh

design facts....on

WALDRON
High
Misalignment
Series "X"





COUPLING SIZE	H.P. PER 100 R.P.M.	MAX. BORE RIGID HUB A	MAX. BORE GEAR HUB B	C	D	E	F	G
1¼X	3½	1⅜	1¼	3¾	2	2⅛	¼	2
2X	12	2⅛	2	4 17/32	2⅞	2⅜	5/16	2¼
2½X	26	2¾	2½	5 5/16	3⅝	2¾	⅜	2¾
3X	50	3⅜	3	6 1/32	4¼	3¼	7/16	3¼
3½X	86	4	3½	7⅜	5	3¾	7/16	3¾
4X	130	4½	4	8 7/32	5¾	4¼	½	4¼
4½X	210	5¼	4½	9 7/16	6½	4¾	½	4¾

The Series X coupling is specifically designed for transmission of power in applications where shaft misalignment is too great to be handled by a standard gear coupling.

Each coupling assembly has two rigid hubs, mounted on drive shaft and driven shaft, each connected to a one piece sleeve by a spline used for driving purposes only. This spline extends only a portion of the hub length, and the remaining length of the hub is a turned surface which fits snugly into the counterbore in the sleeve to provide a suitable bearing surface. These two sleeves are connected by a floating shaft on both ends of which are mounted flexible hubs with gear teeth of unique design which permits misalignment up to 5°.

Series X couplings are easy to dismantle and reassemble. By backing off the set screws, the sleeves can be disengaged from the rigid and flexible hubs. Specially designed seals and steel protecting rings are held in place in the sleeves with Spirolox rings. End portions of the gear hubs are tapered for easy reentry of the seal in reassembly.

All load carrying parts are machined from high strength alloy steel. Floating shafts to customer specifications have nylon plugs inserted in each end to limit axial float and to prevent damage to the lathe centers of the roll shafts.

Write for Catalog

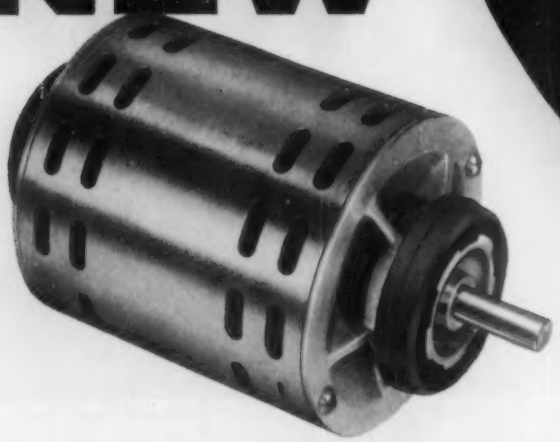
WALDRON Couplings
MIDLAND-ROSS

WALDRON-HARTIG DIVISION
MIDLAND-ROSS CORPORATION
BOX 791, NEW BRUNSWICK, N. J.
SALES REPRESENTATIVES FROM COAST TO COAST

CIRCLE 29 ON READER SERVICE CARD

Now! Pay less for fractional H.P. Induction motors with this new lower cost Howard model

NEW



Howard offers a complete line of

For typewriters, Business Machines, Tape Recorders, Record Players, Appliances . . . Quality construction and performance at Lowest Prices!

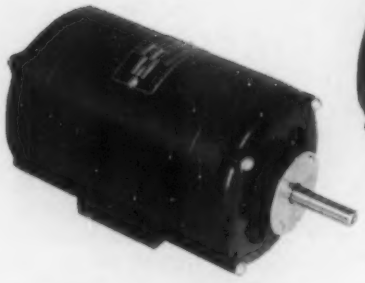
4 pole ratings from 15 milli-h.p. to 1/20 h.p. • Available in hysteresis synchronous, permanent split capacitor, split phase and capacitor start models • 3" diameter • Single or double shaft • Mounting and performance characteristics designed to your requirements • Sturdiest frame in the small motor field

Howard now has the privilege of offering this powerful new top quality induction motor at almost shaded pole prices—an opportunity affording tremendous economies for manufacturers of a wide range of products. If you have an induction application in the works or a project in mind, send us your specifications and we'll rush you a sample. Check its construction and performance . . . then note the price. This is an extraordinary value, demanding your attention. Contact us today.

Write for samples and prices on this new cost-cutting induction motor

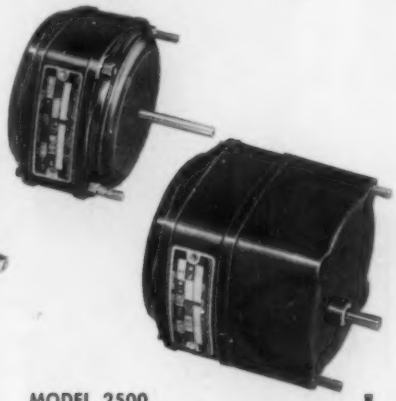
RATINGS FROM 1/1400 TO 1/4 H.P.

Shown below is a representative selection of the Howard induction line. A wide range of standard motors and variations in synchronous, non-synchronous, hysteresis, torque and servo types is available for quick delivery. Send us details of your application—check with Howard before you specify.



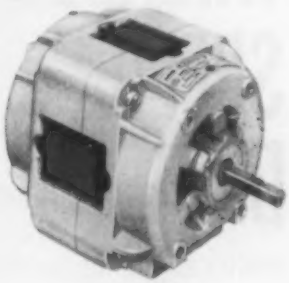
MODEL 2900

TYPE: 2 Pole, 4 Pole, 6 Pole or 8 Pole Induction.
DIAMETER: 3-5/16".
LENGTH: 4-25/32" to 5-21/32" ball bearing.
5-5/16" to 6-3/16" sleeve bearing.
H.P.: *1/70 to 1/15.
FULL LOAD TORQUE OZ. IN.: *10.0 to 30.
BEARINGS: Bronze sleeve type with oil reservoirs, or permanently lubricated sealed and shielded ball bearings.
*Dependent on type of motor used: i.e. Non-Synchronous Capacitor Motors, Standard synchronous, Motors, Hysteresis Synchronous Motors. Torque Motors.



MODEL 2500

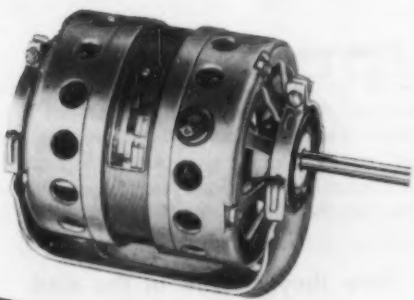
TYPE: 2 pole or 4 pole induction.
DIAMETER: 2-9/16" square.
LENGTH: 1-7/8" to 2-3/8".
SPEED: *1200 to 3600 R.P.M.
H.P.: 1/300 to 1/1400.
MAXIMUM TORQUE OZ. IN.: *1.6 to 3.5.
BEARINGS: *Ball or sleeve.
*Dependent on type of motor used, i.e. Non-Synchronous Capacitor Motors, Torque Motors, Standard Synchronous Motors, Hysteresis Synchronous Motors.



MODEL 9200

TYPE: Induction, torque, synchronous 2, 4, 6 or 8 poles, 25 to 60 cy single (capacitor) two or 3 phase.
H.P.: 1/250 to 1/50 continuous or intermittent duty.
R.P.M.: 900 to 3600.
DIMENSIONS: 2-7/8" x 2-7/8" by 4-1/32" to 4-13/32".
MOUNTING: Pad, resilient ring, face extended bolts.
BEARINGS: Porous bronze sleeve, (ball bearings available at request).

fractional H.P. Induction Motors



MODEL 3700

TYPE: 2 Pole, 4 Pole, 6 Pole or 8 Pole Induction.
DIAMETER: 3-7/8".
LENGTH: 5-1/16" to 5-11/16".
H.P.: *1/25 to 1/7.
STARTING TORQUE: *13 oz. in. to 30 oz. in.
BEARINGS: Porous bronze type with oil reservoir.
*Dependent on type of motor used; i.e. Normal Induction Motor, Hysteresis Synchronous Motor.

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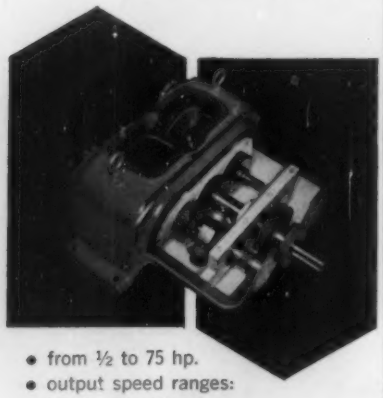

- from ½ to 75 hp.
- output speed ranges: 0-100 to 0-7000 rpm
- smoothly adjustable through zero speed
- draw accuracies of .01%
- full torque at zero speed

These are just some of the outstanding characteristics of Specon variable speed drives. Rugged, reliable and requiring minimum main enance, they permit infinitely fine adjustment of output speed with accuracies approaching fixed gearing. Specon drives also feature shockless starts and acceleration, full reversing, and provide output speeds up to 7000 rpm while maintaining zero speed features.

Send for FREE data booklet on Specon variable speed drives.

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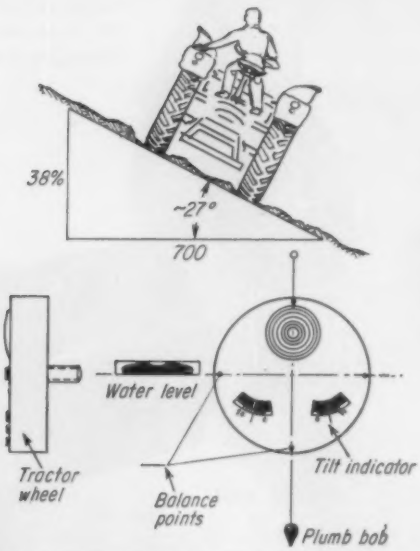


ANTI-TOPPLE ALARM uses clamped, weighted horizontal balance as reference to indicate degree of vehicle tilting. As the diagram indicates, vertical and horizontal positioning of the unit with respect to the axle is a critical factor.

Germans design tip tipoff

An anti-topple alarm for trucks, tractors, construction and mining machinery, and agricultural equipment has been designed in West Germany, and is available for export. It provides both an optical and acoustical signal—the former by means of a small indicator gage mounted on the dashboard; the latter by connection to the vehicle's horn. A signal light can also be provided. Furthermore, says Siegfried Riefler, Nesselwang/Bayern, Postfach 57, West Germany, the unit can be preset to warn at the proper angle for each vehicle; and it is tamperproof.

Help for the harried homeowner

Building, buying, or bolstering the old homestead? The Government Printing Office has 57 varieties of publications, priced from 10¢ to $3.50, but most in the 10¢-75¢ range to help out. Examples:

Heat-loss calculations (54 pages) 40¢
Painting, repairs and utilities (147 pages) 40¢
Modular coordination (29 pages) 25¢

For a free list of government publications for homeowners and builders write GPO, Washington 25, DC.

Time marches on—electronically

Wrist watches without springs or escapements—lacking, indeed, most of the troublesome conventional parts—can be on your gift list this fall. These are "electronic" watches. They'll be battery-operated; but, unlike the earlier-introduced "electric" watches, they'll sport solid-state circuits in place of the conventional watch mechanisms. At least one company has several prototypes out on test; and there may be others before the fall deadline nears.

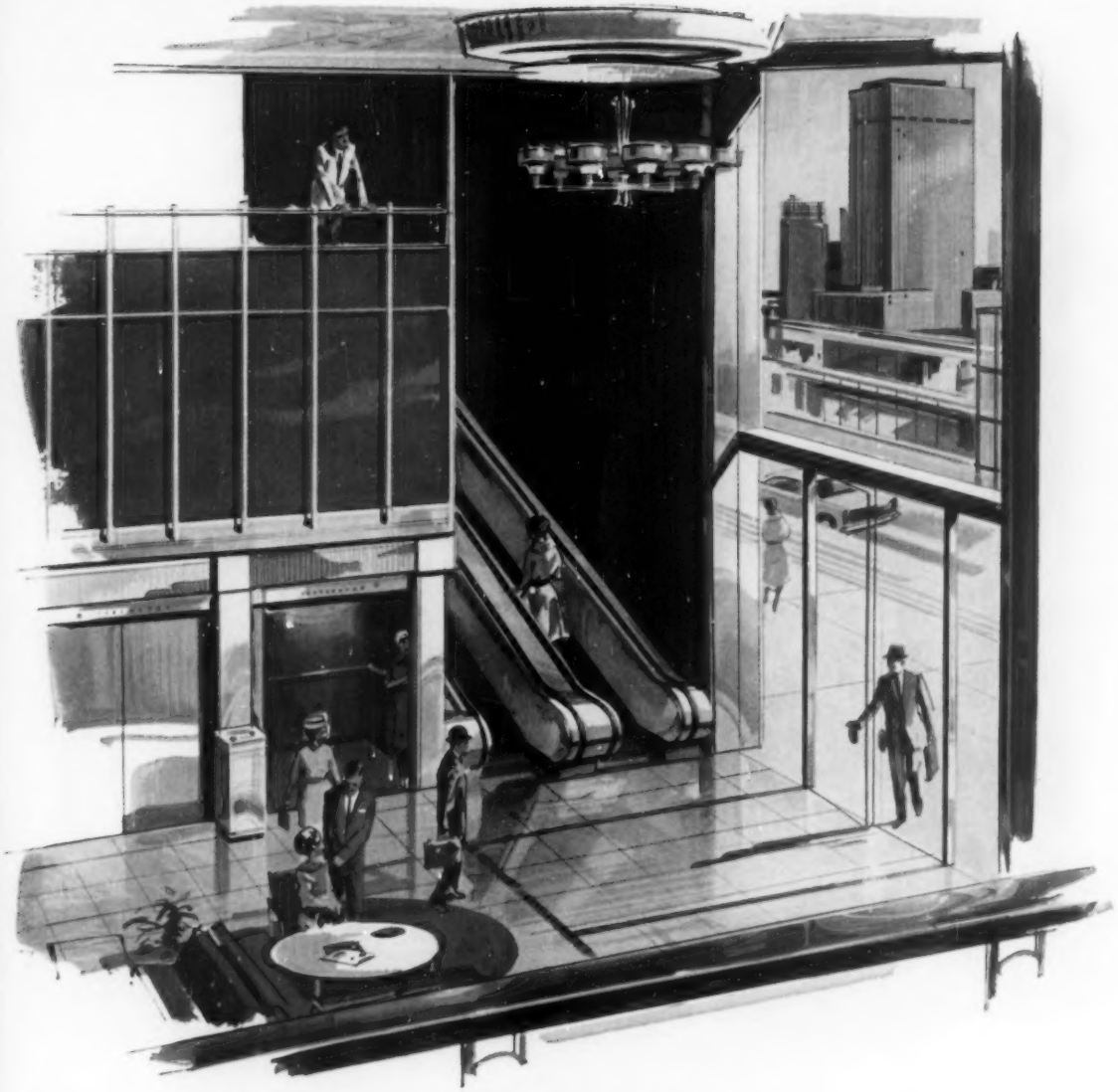
Now they'll write in the dark

A ball-point pen that carries its own miniature light bulb and battery is being imported from West Germany by Hoffritz for Cutlery. It's not quite 7 in. long; about half an inch in dia; takes a 1.5-v miniature bulb and "C" battery.

The front end of the barrel, of transparent acrylic plastic, pipes the light to the job. The light goes on automatically when the point is extruded; but a switch in the barrel makes it possible to turn it off for "day writing." It's available in gold or chrome finish. Price: $4.95, postpaid, with bulb and battery. Ballpoint refills, plus bulb, are $1 per package.

(Note: For engineering applications of miniature lamps, see page 57.)

—ARG



stainless steel

No other metal has the strength and beauty of Stainless Steel. In heavy use areas and for weather exposed panels and trim, its hard lustrous finish is easy to clean and economical to maintain for the life of a building. For the architect and the builder no other material performs so well today and promises so much for tomorrow.

here is nothing like stainless steel for ARCHITECTURE

Look for the **STEELMARK** on the products you buy.

McLouth Steel Corporation,
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Whatever your job, wherever it takes you, you'll always find a Ford Dealer nearby to give quick assistance in solving any industrial engine problem.

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News! The best features of
modern bearing design combined and refined in

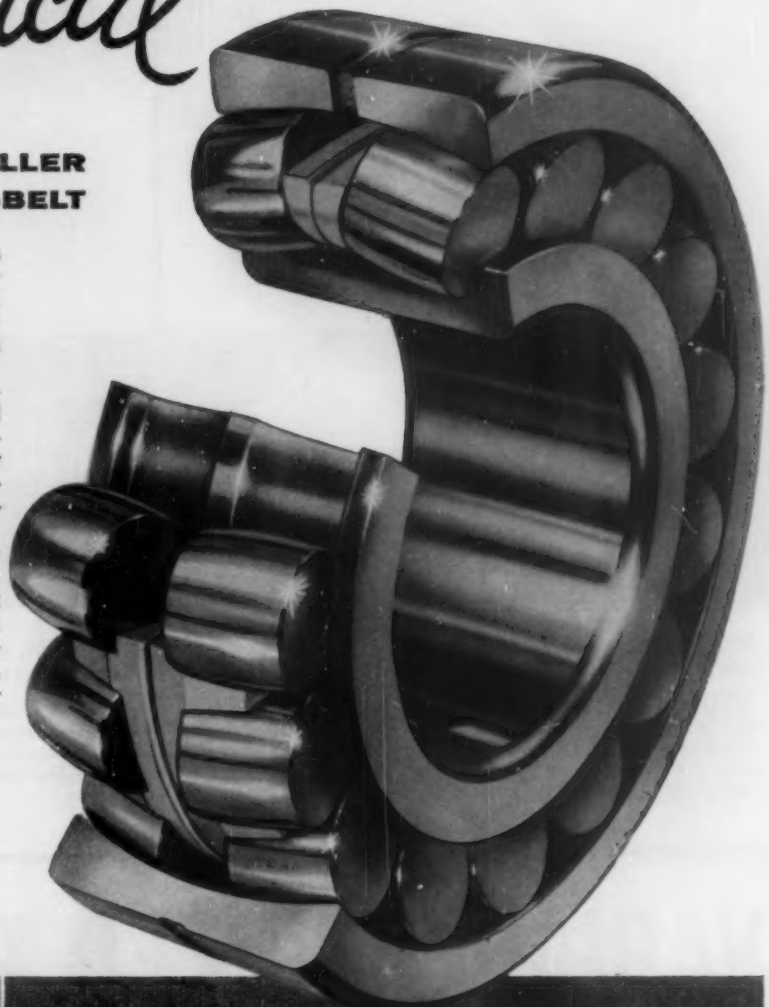
Spherical

SELF-ALIGNING ROLLER BEARINGS BY LINK-BELT

BIG, mirror-smooth convex rollers *plus* heavy, broad-shouldered inner race *plus* centrifugally-cast bronze, precision-machined retainers! Only from Link-Belt do you get ALL that is best in modern bearing design.

Individually, these elements represent major improvements on accepted design concepts. Collectively, they constitute the most efficient spherical roller bearings available . . . promise unequalled economies, whatever the application.

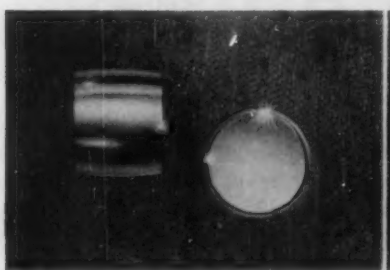
Your Link-Belt office will gladly explain the many performance advantages evolved with this new design. It can furnish full data on industry's most complete line of ball and roller bearings . . . pillow blocks and flanged, flanged-cartridge, cartridge, and take-up blocks.



LINK-BELT

MANUFACTURERS OF SELF-ALIGNING BALL AND ROLLER BEARINGS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. Plants, Sales Offices and Distributors in All Principal Cities. 14,819-A



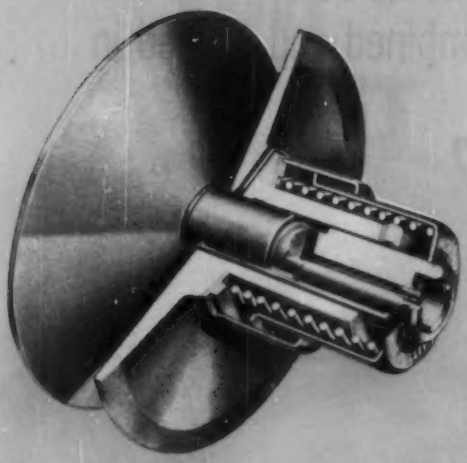
BIG, HIGHEST-CAPACITY ROLLERS. Each bearing has a maximum number of rollers —as large as possible, yet all components are in optimum balance.

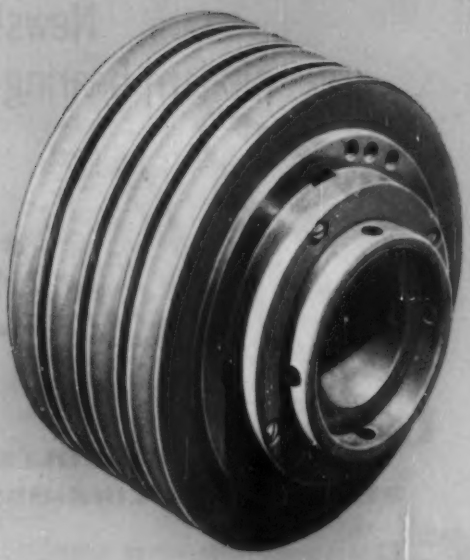
HIGH, HEAVY INNER RACE FLANGES present convenient hold for assembly and removal of bearing without cutting away shaft, avoid any need to skimp on shaft shoulders.

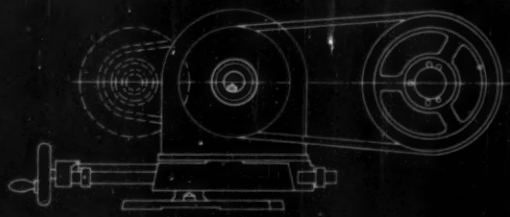
PRECISION-MACHINED, CENTRIFUGALLY-CAST BRONZE RETAINERS have many times more support and ability to withstand high stress. They are not stampings. Design assures maximum bearing efficiency.

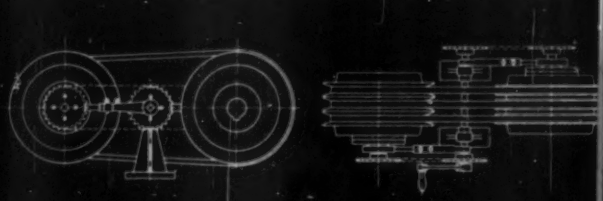
CIRCLE 35 ON READER SERVICE CARD

CIRCLE 36 ON READER SERVICE CARD →









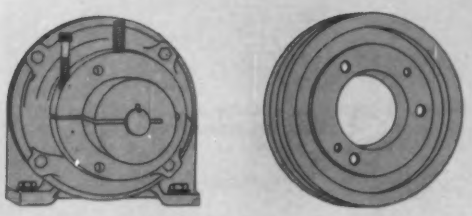
PROBLEM: Need 15 hp and up to 3:1 continuous speed variation with equipment running.

SOLUTION: For horsepowers from ⅛ to 15, use Worthington Motor Pulley drive with Anglematic motor base. The Anglematic motor base allows continuous speed control while maintaining belt alignment. It keeps the motor pulley design simple, trouble-free; two-piece companion sheaves have separate hubs and the 2 "Golden Screws" for easier, more dependable installation.

PROBLEM: Need less than 2:1 speed variation on 500 hp installation, with equipment running.

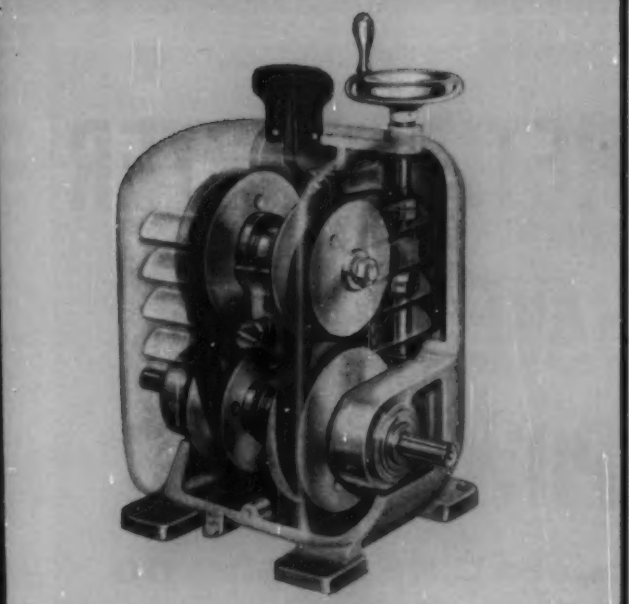
SOLUTION: Use the motion control Multi-Pitch sheaves. For fixed center drives and maximum variation, use a double motion control drive arrangement. For applications not requiring speed changes with equipment running, choose the less expensive stationary control Multi-Pitch sheave.

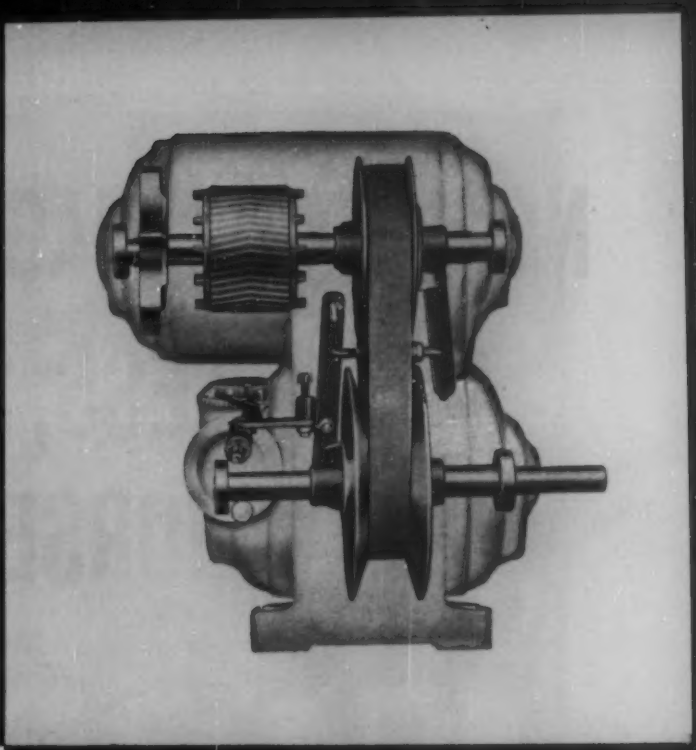
VARIABLE SPEED PROBLEMS

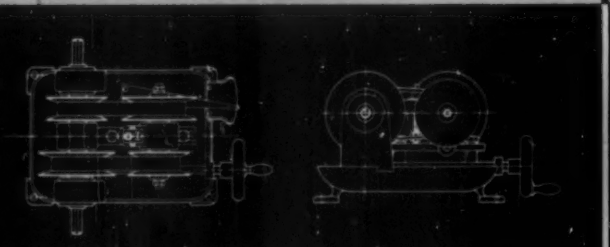


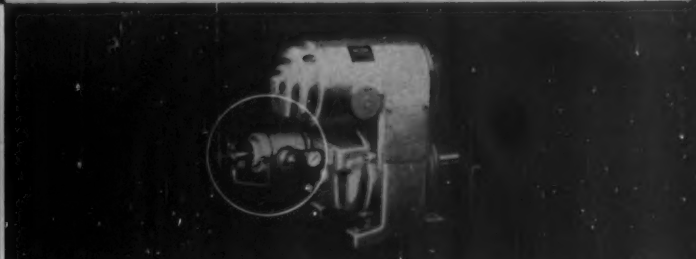
You need, of course, just one right answer to any variable speed problem. But if your answer is based on a choice from four stock Worthington variable-speed drive types and their hundreds of standard variations, chances are your final solution will be the best one. Certainly, you'll get compact design, accurate speed control and long

Motor Pulley and Multi-Pitch Sheave drives require companion sheaves. Both types of Worthington companion sheaves are equipped with the famous QD hub with the "Golden Screws" for permanent alignment and prevention of key drift. For longest belt life, select Worthington-Goodyear belts.









PROBLEM: Need 150 to 3000 rpm stepless speed variation while equipment is running.

SOLUTION: Use Worthington Allspeed Drive that can give up to 20:1 speed variation without stopping equipment. Compact design has straight through shaft for very simple installations with direct or other couplings. A skeleton frame or enclosed frame, in horizontal or upright types make installation even more easy and compact and any frame can be at any angle.

PROBLEM: Need automatically controlled speed variation as high as 10:1 in continuous process.

SOLUTION: Use sensing or monitoring device that converts production variations such as pressure, temperature, time, speed or liquid levels—to pneumatic pressures. Connect it to Worthington Variable Speed Motor drive equipped with pneumatic cylinder that actuates speed variation in direct proportion to any change in input signal. Electric, lever and remote hand controls also available. Horsepowers from ½ to 25.

. . . FOUR STOCK ANSWERS

equipment life—all at a very competitive cost for the job you want done.

To help you, Worthington variable speed drive catalogs contain complete "how-to-figure-it" engineering information, as well as product information. You can get them from your nearest Worthington representative or distributor listed in the Yellow Pages. Or use the coupon at the right.

WORTHINGTON

WORTHINGTON CORPORATION
Section 79-31, Oil City, Pa.

Please send me your new catalogs on the following variable speed drive components:

- ☐ Multi-pitch Sheaves
- ☐ Motor Pulley Drives (1 to 15 hp)
- ☐ Motor Pulley Drives (Fractional hp)
- ☐ Motor Drives
- ☐ Allspeed Drives
- ☐ Variable Speed V-Belts

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Square D NEMA Size 00 Starter Rated ¾ to 2 Hp for 3-Phase Service

• You no longer need to buy more starter capacity than you can use for low-horsepower jobs! This new Square D Size 00 starter is compact, easy to install, simple to use and maintain—and it costs 18% less than the Size 0 starter you formerly had to specify to get the advantages of magnetic control! With no sacrifice in quality, this new starter provides: straight-through wiring—pressure-type terminals—1-piece overload relays for complete motor protection—pushbutton or selector switch optional in the cover. Also available without overload relays.

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New starter is available either open or in NEMA Type 1 enclosure. Enclosure shown with selector switch in cover.

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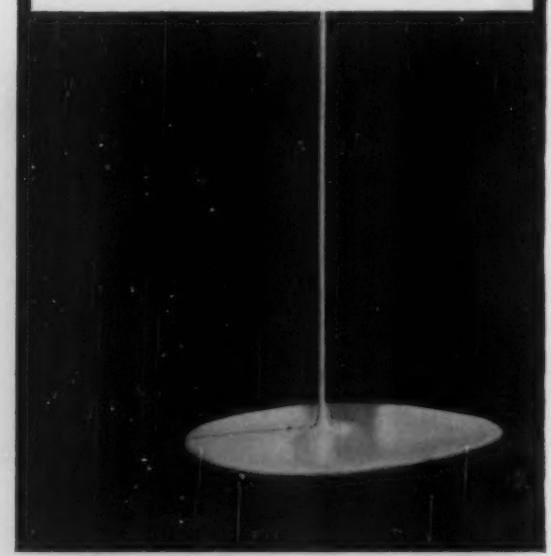
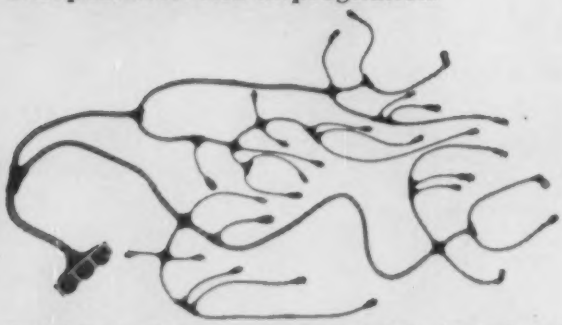
New low viscosity for easier encapsulation and impregnation

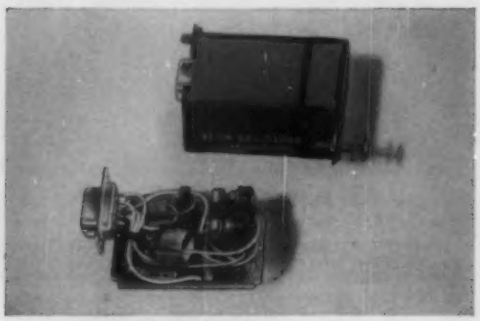
The latest addition to General Electric's RTV family offers lower viscosity than any other available silicone rubber compound — a typical viscosity of 120 poises. Easily pourable, it flows freely in and around intricate contours, making it ideal for protecting electrical and electronic components.

With RTV's new low viscosity, the range of G-E RTV compounds now extends from 120 to 12,000 poises. You can now meet your specific requirements by selecting from several G-E RTV compounds, all of which offer room temperature cure, heat and ozone resistance, and good electrical properties. Write for a free test sample, briefly describing your application.

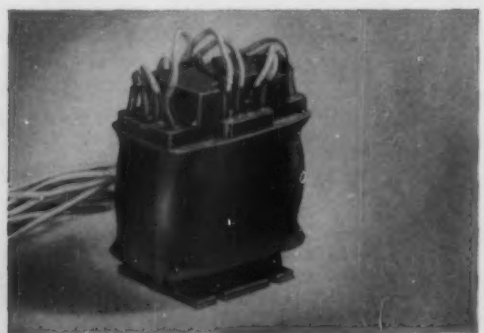




General Electric silicone rubber used extensively by Aerojet-General Corp. for the Titan ICBM's propulsion-system wiring harness. Tubing is heat-cured silicone rubber, molding G-E RTV and wiring insulated with silicone rubber — all chosen for their stable insulating properties, resistance to temperature extremes and weathering, and stability in storage for many years.



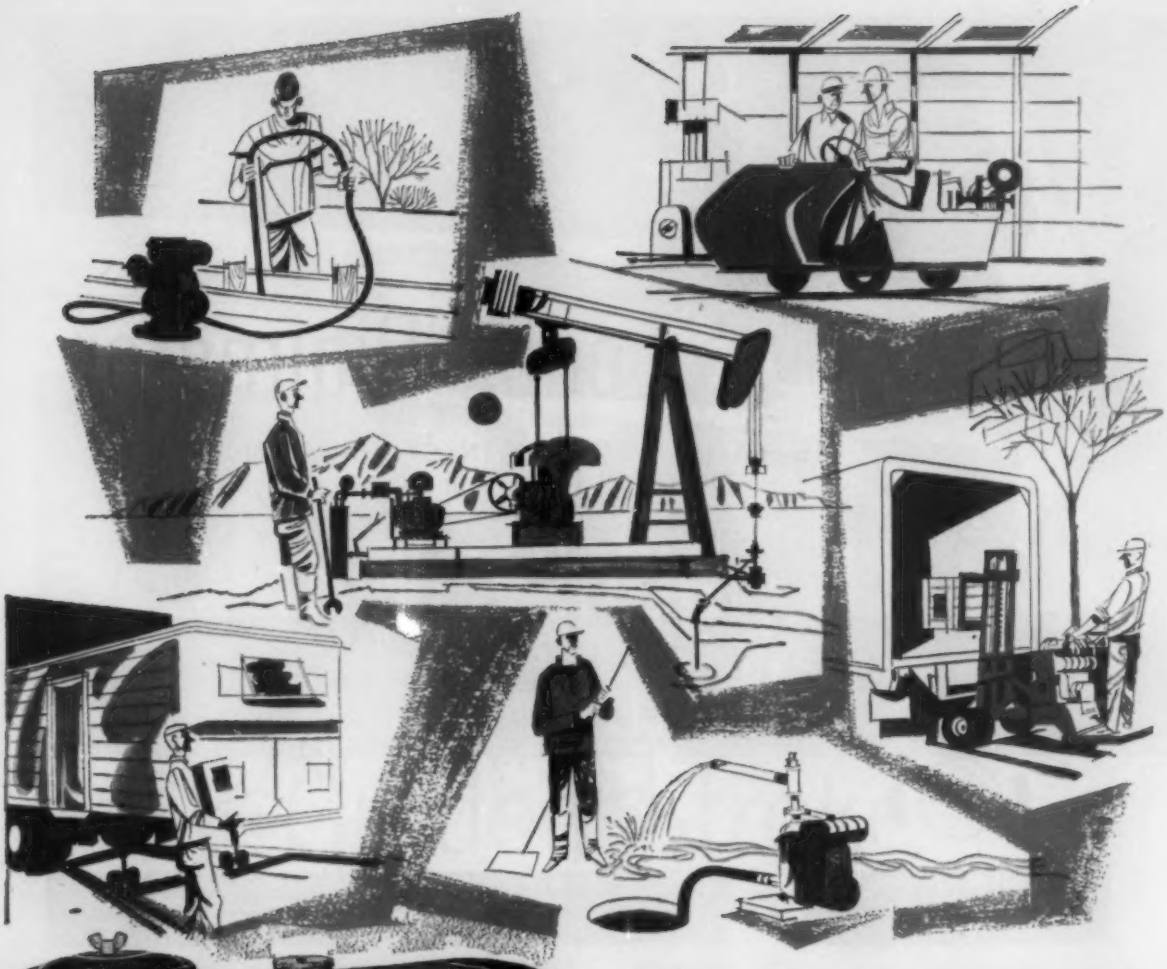
Sight amplifier module potted with RTV by the Armament and Control Section of G.E.'s Light Military Electronics Department. Used on the Lockheed CF-104 and F-104G jet aircraft, RTV provides mechanical support and vibration damping, protects unit against moisture and ozone. (Bottom photo shows module before potting.)



High-voltage, high-altitude transformers from Laboratory For Electronics, Inc. are encapsulated with General Electric RTV to meet MIL-T-27A specs. This prevents flashover at maximum ratings of 2200 volts rms and 80,000 feet. General Electric RTV was selected for its good heat transfer, low viscosity and mechanical strength.

GENERAL ELECTRIC

Silicone Products Department, Waterford, New York



MODEL
K161
4-cycle
Short stroke
Air-cooled

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Kohler engines are rugged, quick-starting in all weather, conservatively rated. Short stroke design gives maximum usable power, cuts engine friction.

Sold and serviced through a nation-wide organization, Kohler engines are increasingly being installed on a wide variety of construction, agricultural and industrial equipment. They power Kohler electric plants, known everywhere for reliability.

Kohler Co. has manufactured internal combustion engines for 40 years.

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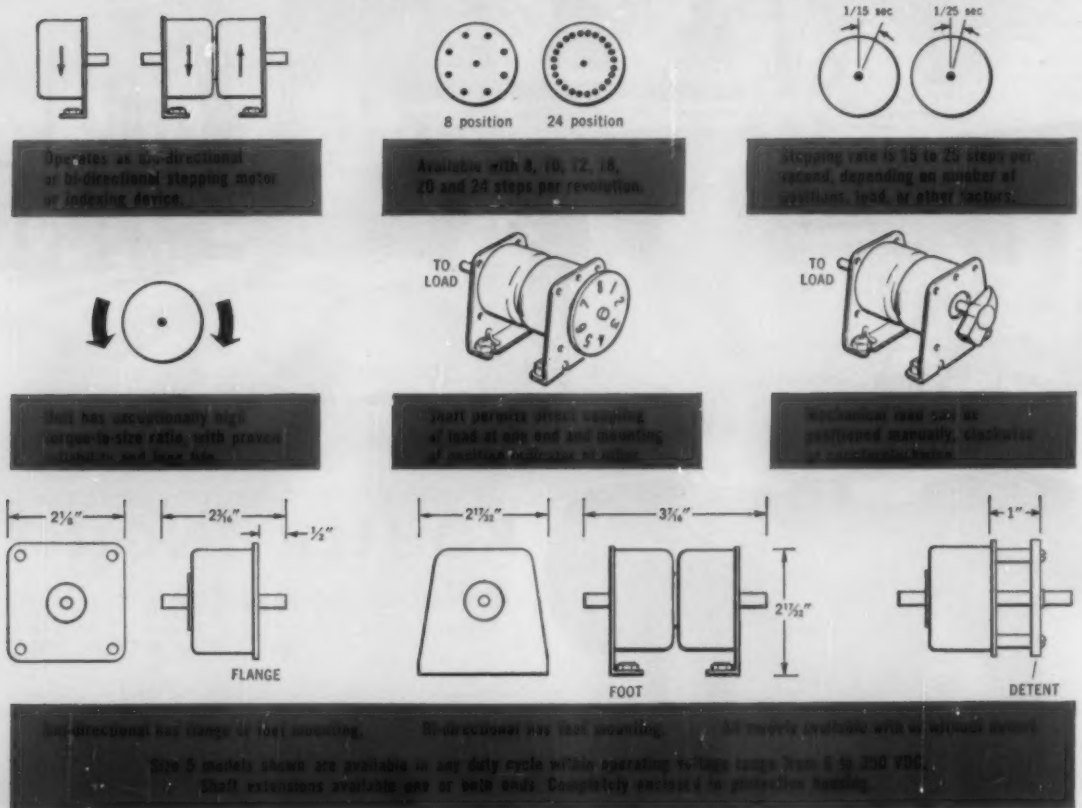
ENAMELED IRON AND VITREOUS CHINA PLUMBING FIXTURES • BRASS FITTINGS • ELECTRIC PLANTS • AIR-COOLED ENGINES • PRECISION CONTROLS

New Ledex Digimotor®

IS MAJOR ADVANCE IN STEPPING MOTOR FIELD



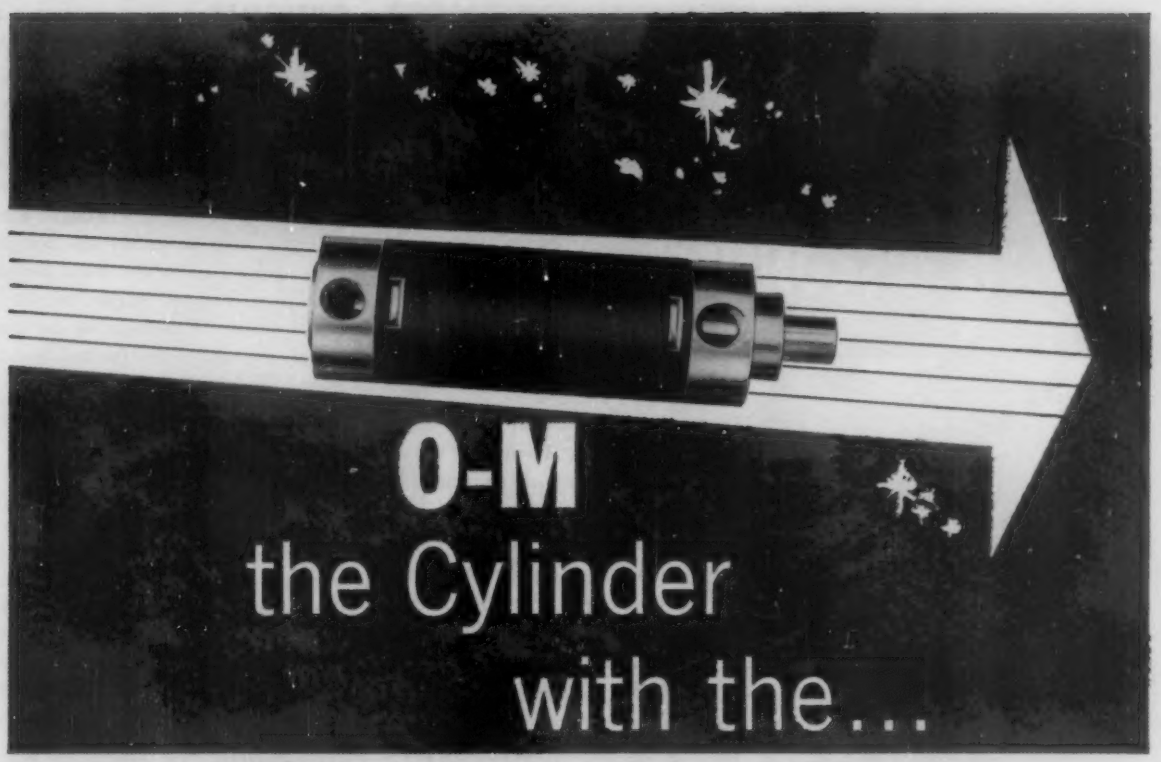
The new Ledex *Digimotor* is a stepping motor or indexing device with exceptionally high reliability and torque-to-size ratio. Its new design concept gives it features never before available. Size 5 stock models come in a variety of shaft positions and in any duty cycle within a wide operating voltage range. It is jam proof, permanently lubricated, has magnetic anti-overcoast, and operates at "whisper" noise level.

New Ledex *Digimotor Switches* are rotary selector switches with all advantages of the Digimotor drive plus other special features.

LEDEX®

Ledex, Inc. was formerly G. H. Leland, Inc.

Other Ledex products include Rotary Solenoid, Rotary Solenoid Selector Switch, Hermetically Sealed Selector Switch, and *Syncramental* Stepping Motor. Mechanical applications include actuation of valves, vanes, printers, shafts. Switching applications include circuit selecting, stepping, counting, programming and sequencing. Write for literature, mentioning application, to Ledex, Inc. (formerly G. H. Leland, Inc.), Dayton 2, Ohio; Marsland Engineering, Ltd., Kitchener, Ont.; NSF Ltd., 31 Alfred Place, London, Eng.; NSF GmbH, Nurnberg, Germany.



Guided Stroke

INTERNAL KEY TIE-RODLESS-TYPE SERIES 101A

Air 150 psi—Hydraulic up to 1500 psi
Fits where others won't
Meets JIC Standards, Bulletin 101A

WHEN a piston rod must hit right on the button to feed a work piece, activate an indexing table, push, pull, raise, lower, knock-out or clamp, you can count on an O-M Guided-Stroke Cylinder everytime. And there's no mystery about it, just top-level O-M precision workmanship, the latest and best machine tools, modern design, plus years upon years of engineering "know-how." And it's all spelled out with construction and performance details, engineering drawings as well as a capacity chart in each of our latest Bulletins.

Write for your copy TODAY. See why O-M Air and Hydraulic Cylinders maintain perfect rod alignment, make full-power starts, are designed right to seal right, have the lowest coefficient of friction and many other advancements.

Bulletin 101A for Internal Key Tie-Rodless-Type Air and Hydraulic Cylinders featured above.

Bulletin 105A—Improved Tie-Rod (Heavy Duty) Cylinders Hydraulic 2000 psi; 3000 psi non-shock.

Bulletin 107—Automation (Heavy-Duty) Air Cylinder for 200 psi operation.

Bulletin 108—Automation (Heavy-Duty) Hydraulic Cylinder—for 1000 psi operation.

All O-M Cylinders are available in ½" to 8" bores with standard, oversize, or heavy-duty rods. Complete line of mounts and interchangeable parts. Immediate delivery on most sizes. MAIL COUPON TODAY.

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☐ 101A ☐ 107
☐ 105A ☐ 108

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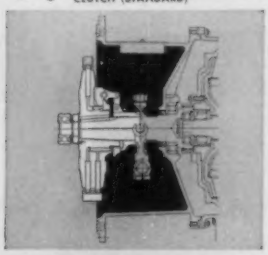
NEW From TWIN DISC . . .
Single-Stage Torque Converter WITH DISCONNECT CLUTCH

"C" WITH FRONT-END DISCONNECT CLUTCH (STANDARD)



"O" WITH OVERSPEED OR BOOM-LOWERING FREEWHEEL

"G" WITH 2:1 RATIO OUTPUT REDUCTION GEAR

IN THE APPLICATION of single-stage torque converters, Twin Disc's new *Model C* units provide considerable design flexibility. These clutch-equipped converters are offered in three input torque capacities: 350 lb-ft (1300 Series); 450 lb-ft (1500 Series Standard-Duty); and 650 lb-ft (1500 Series Heavy-Duty).

All Model C units feature an 11" front-end disconnect clutch—single-plate on the smaller series; two-plate for capacities above 350 lb-ft. Both clutches are mechanically actuated types with driving rings that fit standard SAE over-center flywheels.

OPTIONAL
Boom-Lowering Freewheel

For the shovel and crane industry, Twin Disc has designed a special converter—*Model CO*—with a cam-and-roller freewheel between the impeller and the turbine. This permits the converter to function as a straight mechanical drive whenever the output shaft is driving. As the boom begins to fall of its own weight, the freewheel locks the turbine to the impeller, making engine friction horsepower available for braking.

OPTIONAL
Output Reduction Gear

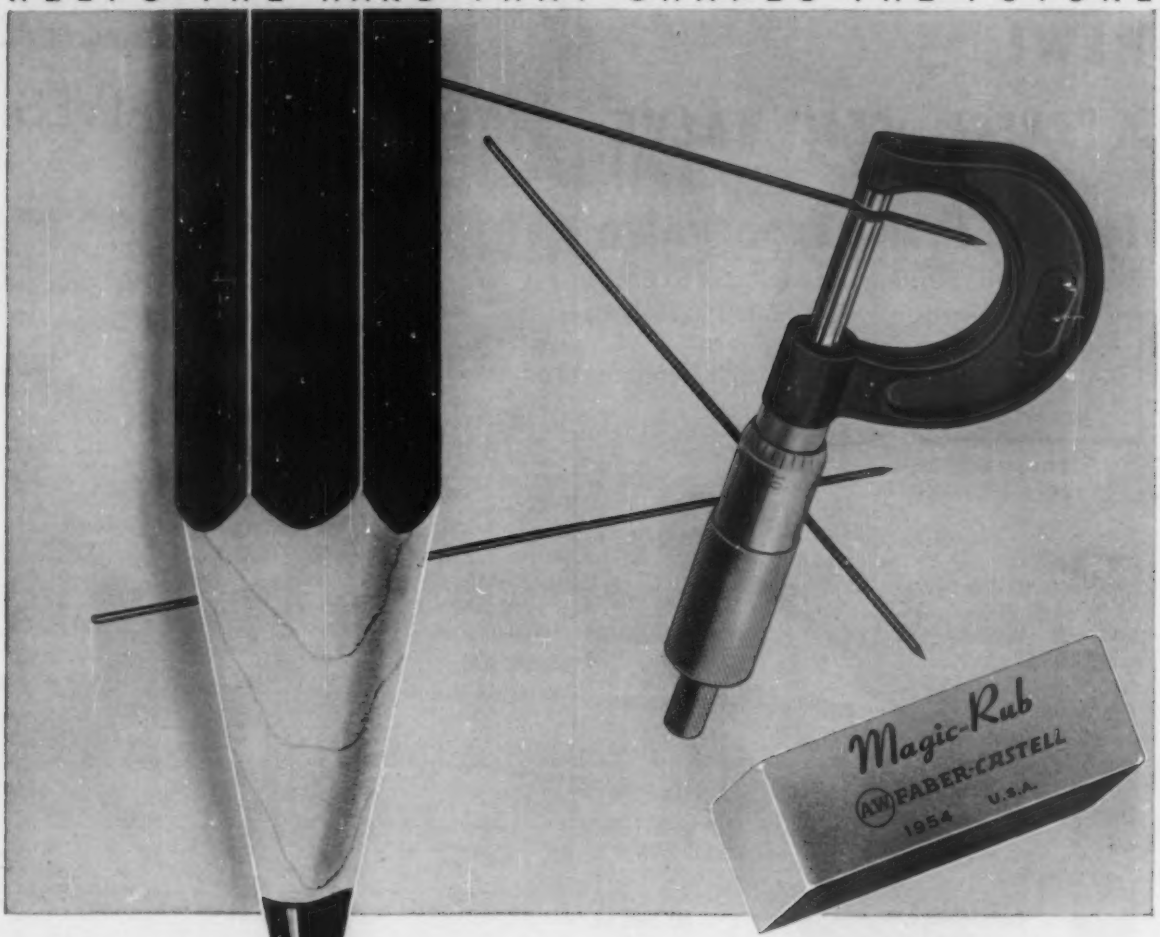
For installations using high-speed engines but requiring lower output shaft speeds, Twin Disc can furnish a 2:1 ratio reduction gear. It bolts to the rear of all Model C and CO converters and is capable of carrying output shaft side loads. The gear can be mounted in the field without design change.

New Bulletin 510, containing engineering data on 25 models of Twin Disc Single-Stage Torque Converters, is available on request from our Rockford office.

TWIN DISC
Torque Converters

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • Hydraulic Division Rockford, Illinois

HELPS THE HAND THAT SHAPES THE FUTURE



CASTELL LIGHTS UP THE PATHS OF PRECISION

Man's creative ability and the tools that help him express it! Fortunate are those who toil in the vineyard of architecture, engineering, designing and drafting. For a few cents they can buy CASTELL, the world's finest drawing pencil, partner in progress the world over. This needs restating only for the benefit of the young now coming up in the profession. Old seasoned hands have known it for generations. CASTELL is an unquestioned fact in a creative man's life.

#9000 CASTELL Pencil with world's finest natural graphite that tests out at more than 99% pure carbon. Exclusive microlette mills process this superb graphite into a drawing lead that lays down graphite-saturated non-feathering lines of intense opacity for cleaner, more durable originals and clearer, sharper prints. Extra strong lead takes needlepoint sharpness without breaking or splintering. Smooth, 100% grit-free consistently uniform pencil after pencil, in full range, 8B to 10H.

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#9800SG CASTELL LOCKTITE TEL-A-GRADE Holder, perfectly balanced, lightweight, with new no-slip functional grip that lightens finger pressure without slipping, and *relieves finger fatigue*. Unique degree lead indicating device.

#9030 CASTELL Refill Lead, matching exactly #9000 pencil in quality and grading, degrees 7B to 10H, packed in reusable plastic tube with gold cap.
Many other styles and colors of CASTELL Pencils, Holders and Refill Leads.

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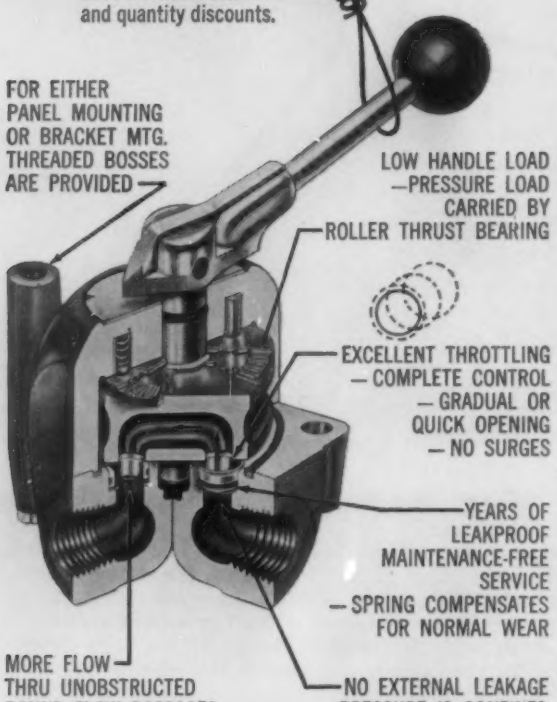
A "SHEAR-SEAL" VALVE

for LESS than a spool valve

RATED FOR 3000 P.S.I. OIL SYSTEMS

$65.00
List Price*
for a ¾" valve

*Less the usual O.E.M. and quantity discounts.


FOR EITHER PANEL MOUNTING OR BRACKET MTG. THREADED BOSSES ARE PROVIDED
LOW HANDLE LOAD —PRESSURE LOAD CARRIED BY ROLLER THRUST BEARING
EXCELLENT THROTTLING — COMPLETE CONTROL — GRADUAL OR QUICK OPENING — NO SURGES
YEARS OF LEAKPROOF MAINTENANCE-FREE SERVICE — SPRING COMPENSATES FOR NORMAL WEAR
MORE FLOW THRU UNOBSTRUCTED ROUND FLOW PASSAGES
NO EXTERNAL LEAKAGE — PRESSURE IS CONFINED TO FLOW PASSAGES

For complete data on this new valve and for information on all your valve requirements write for Catalog V-59-60

CONTROL VALVE DIVISION

Barksdale valves

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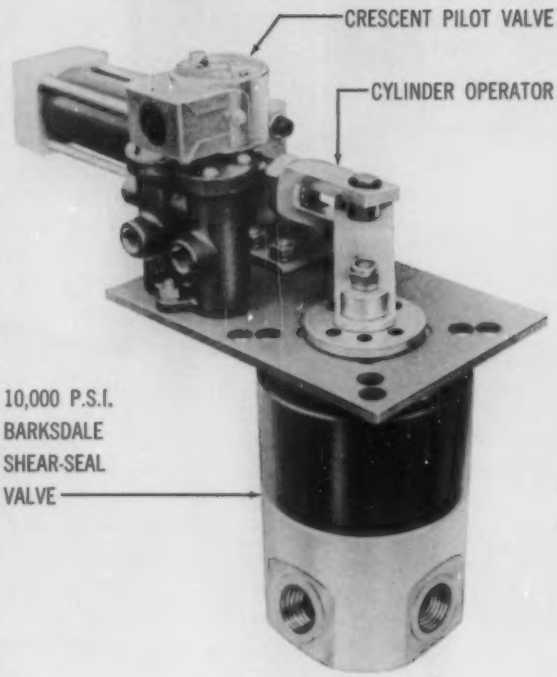
46 CIRCLE 46 ON READER SERVICE CARD

CYLINDER OPERATED

"SHEAR-SEAL" VALVES



Remote control operators for 10000 P.S.I., 6000 P.S.I. and 3000 P.S.I. "Shear-Seal" Valves are available with cushioned or non-cushioned cylinders.

4-Way, 3-Way and Shut-off valves range in pipe sizes from ¼" to 1 ½" N.P.T.

For complete data request catalog COV-60-61.

CONTROL VALVE DIVISION

Barksdale valves

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CIRCLE 204 ON READER SERVICE CARD

SEALING ALUMINUM FLANGES

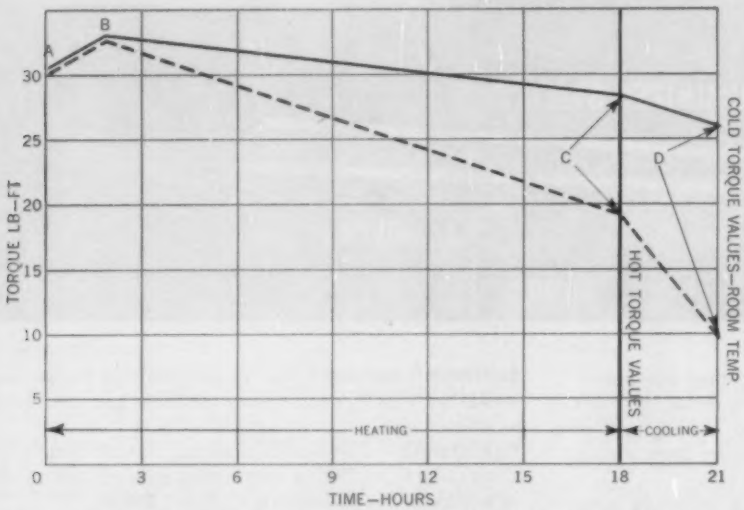
As heat expands aluminum flanges, gaskets often crush and extrude and bolt loading is reduced. New engineering research points way to better seals on these flanges.

E. M. SMOLEY,
Research Physicist
Armstrong Research and Development Center

Where aluminum flanges are used . . . and particularly where they are exposed to alternate cycles of heat and cold . . . crushing and extrusion of gaskets and serious loss of bolt torque are often encountered.

creasing the unit load on the gasket. The consequent crushing and extruding of the conventional fiber gaskets led to substantial loss of bolt torque.

The study also turned up other data unique to aluminum flanges. This is the



This diagram shows effect on torque retention of thermal cycling to 300° F. of gasketed joint with one aluminum flange and one cast iron flange. Torque increase from A to B results from aluminum expansion; B to C represents normal torque loss at constant oven temperature; C to D is loss resulting from aluminum contraction. Solid line is average result of tests with Accopac AN-890, which retains about 90% of the original bolt torque. The dotted line represents average test results with conventional gaskets, which retain only about one-third the initial torque loads after cycling.

To study this problem, Armstrong engineers set up simulated service tests with stock automotive transmission housings. These housings all have large aluminum members that are subject to wide variations in temperature, and all require high flange pressures.

The initial result of the tests indicated—as expected—that the expansion of the aluminum had the effect of increasing the unit load on the gasket. The consequent crushing and extruding of the conventional fiber gaskets led to substantial loss of bolt torque.

The study also turned up other data unique to aluminum flanges. This is the difference between "hot" torque readings—taken while the transmission is at 300° F. and "cold" readings, taken after the assembly cools. With iron or steel flanges, there is no significant difference between these readings. With aluminum, however, the difference often is 20% or more.

The difference between "hot" and "cold" torque readings is a measure of the ability of a gasket to "follow" the flange as it undergoes dimensional change. Ideally, a gasket should show no difference between hot and cold torque readings. It should resist crushing under high pressures and high temperatures—and it should compensate for the contraction of the flange as it cools.

Because conventional materials fall short of these requirements, Armstrong engineers set out to develop a new type of gasket. Their work resulted in a new beater-saturated asbestos material—Accopac AN-890. This new gasket resists crushing under pressures of 100,000 psi at temperatures up to 350° F., and it has superior torque retention characteristics.

If you have a problem with gasket seals on aluminum flanges, our research may be helpful to you. We will be glad to make suggestions if you will submit details of your problem to us.

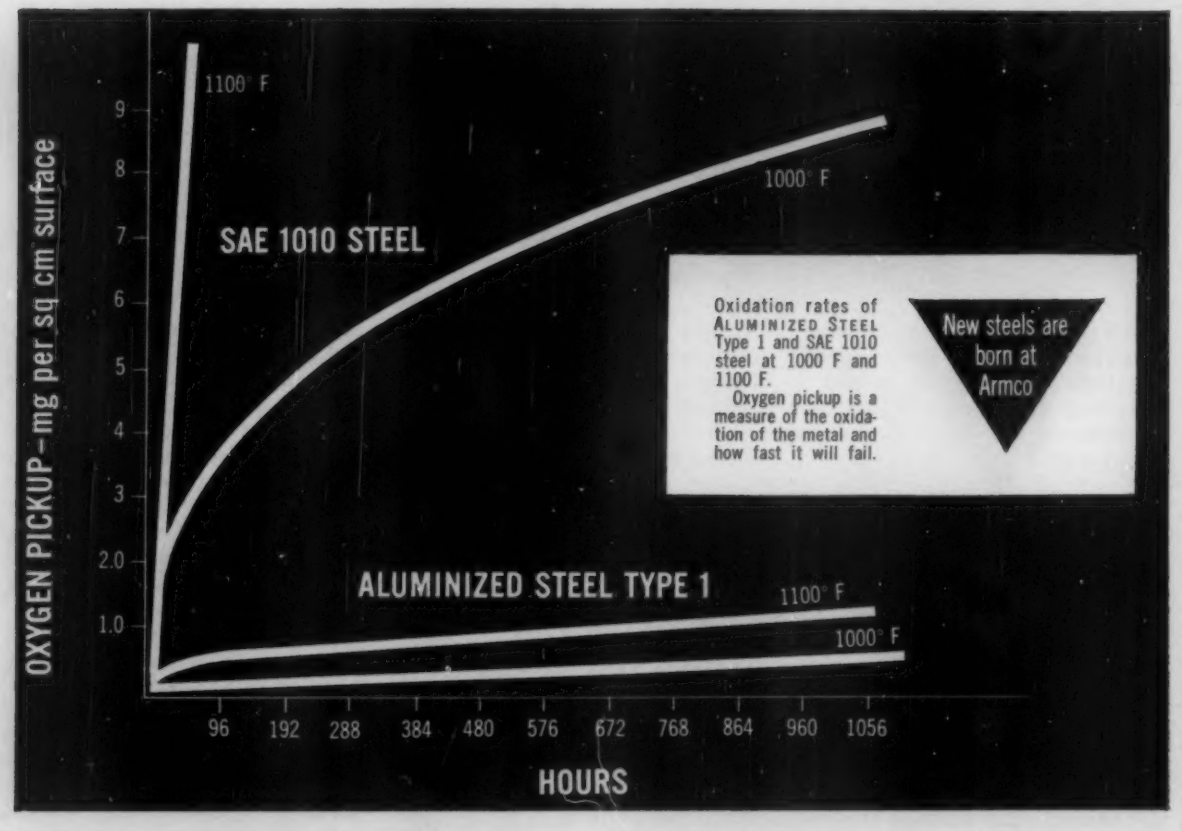
Much detailed information on other problems of gasket design, selection, and performance is contained in the Armstrong Gasket Design Manual. Write today for your copy of this 32-page book.

Address Armstrong Cork Company, Industrial Division, 7107 Irvin St., Lancaster, Pennsylvania.

Armstrong GASKET MATERIALS
1860–1960 Beginning our second century of progress

ARMCO STEELS / for better products • lower costs

WHY AND WHERE ARMCO COST-CUTTING RESISTANCE



These oxidation rate curves show one important reason why Armco ALUMINIZED STEEL Type 1 is so useful for parts that must resist heat. Its hot-dip aluminum coating, applied by a special Armco process, prevents oxygen from scaling the metal at temperatures to about 1250 F.

This union of steel and aluminum also gives you other key advantages that mean better products and lower costs.

High heat reflectivity—at temperatures to 900 F ALUMINIZED STEEL reflects about 80% of incident radiant heat.

Resistance to corrosion—The special aluminum coating withstands the attack of combustion products and condensates as well as heat.

High strength—The steel base of ALUMINIZED STEEL provides design-simplifying, cost-cutting strength and rigidity in service at temperatures as high as 1250 F.

Low Cost—For only a few cents a pound more than cold-rolled steel, you get a two-in-one metal of proved economy for parts that must resist both heat and corrosion.

This versatile aluminum-coated steel provides advantages offered by no other metal. Design its ability to resist heat and corrosion, its heat reflectivity, its strength and economy into **your** products. Write us or mail the coupon for complete information on the properties, fabrication and use of Armco ALUMINIZED STEEL Type 1.

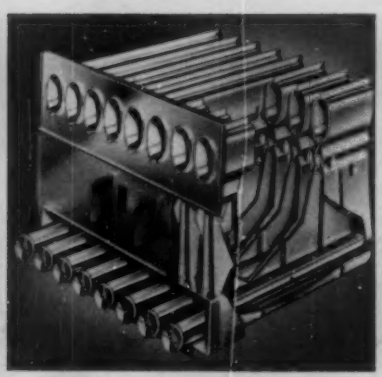
ARMCO STEEL CORPORATION
2440 Curtis St., Middletown, Ohio

Send me complete information on Armco ALUMINIZED STEEL Type 1 for the following applications:_____

NAME_____ TITLE_____
FIRM_____
STREET_____
CITY_____ ZONE_____ STATE_____

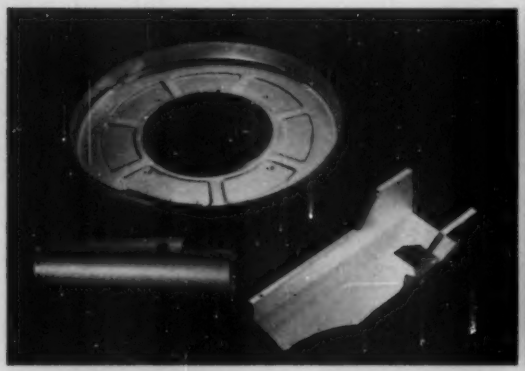
ALUMINIZED STEEL TYPE 1 ASSURES TO HEAT AND CORROSION

Industrial oven

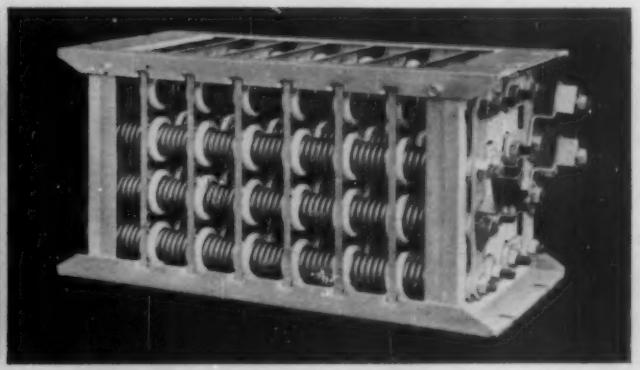


Heat exchanger

Automobile muffler



Laundry drier elements



Electric resistor

The unique combination of properties possessed by ALUMINIZED STEEL Type 1 makes it an effective material in a wide range of applications. For example, manufacturers of appliances such as electric toasters and laundry driers, industrial ovens, and restaurant equipment, use it primarily for its heat reflectivity and corrosion resistance.

In automobile and truck mufflers, the excellent resistance of ALUMINIZED STEEL Type 1 to the combination of heat and corrosion results in greatly extended service life. Use of this metal for the mufflers of many makes of cars is sound proof of its durability and economy.

The ability of ALUMINIZED STEEL to resist oxidation at temperatures to about 1250 F, and to ward off corrosion by condensates and combustion products, has enabled producers of gas and oil fired heaters to achieve greater efficiency and durability at low cost.

For industrial and consumer electric heaters, high heat reflectivity combined with the corrosion resistance and structural strength of this special Armco Steel has meant manufacturing economies plus reliable service.

In addition to these typical applications, Armco ALUMINIZED STEEL Type 1 is specified for many other commercial, industrial and consumer products because it yields new sales advantages and greater durability at lower cost.

ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation

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DEPENDABILITY, ECONOMY and STRENGTH are distinguishing characteristics of these sintered metal automotive transmission parts by Delco Moraine. Vital components such as these are typical results of close collaboration between Delco Moraine and its customers—an effective liaison that operates from idea through design and development. They also attest to Delco Moraine's equally important capabilities for making deliveries in quantity and on time!

DELCO MORAINE

DEPENDABLY MADE parts for industrial progress • Division of General Motors, Dayton, Ohio

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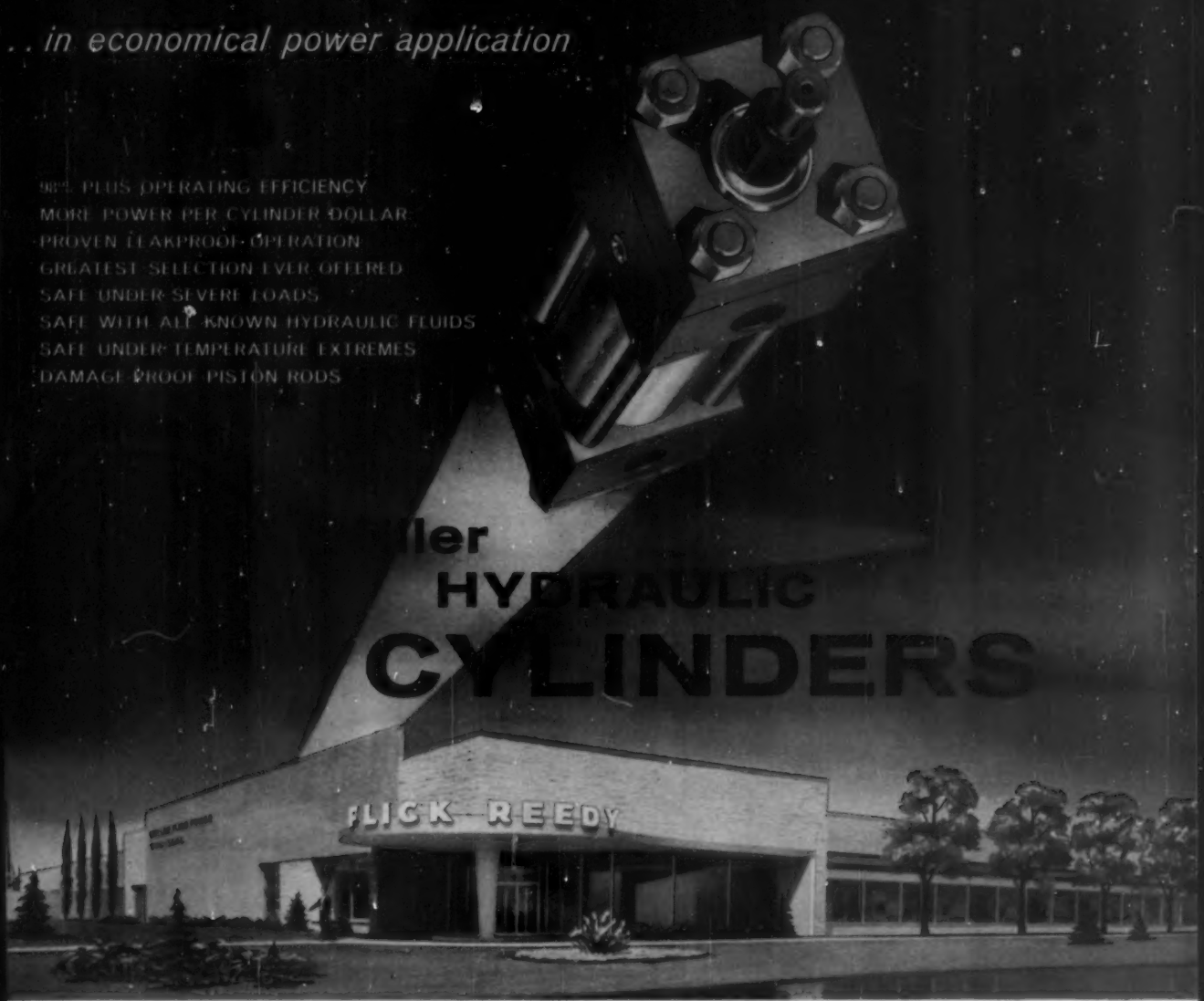
CIRCLE 51 ON READER SERVICE CARD→

OPENING NEW HORIZONS

. . in economical power application

98% PLUS OPERATING EFFICIENCY
MORE POWER PER CYLINDER DOLLAR
PROVEN LEAKPROOF OPERATION
GREATEST SELECTION EVER OFFERED
SAFE UNDER SEVERE LOADS
SAFE WITH ALL KNOWN HYDRAULIC FLUIDS
SAFE UNDER TEMPERATURE EXTREMES
DAMAGE PROOF PISTON RODS



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MORE SAVINGS!

Our ultra-modern, new "Plant of the Year" with its special facilities and operating economies enable us to offer an **extra 10% price savings** on our big "stock" selection of:
Model "H" (Hyd.) Cylinders, 1½" through 8" bores;
Model "J" (Hyd.) Cylinders, 1½" through 14" bores;
Model "A" (Air) Cylinders, 1½" through 14" bores.
Strokes up to 36", cushioned and non-cushioned.

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Miller Hydraulic Cylinders make impossible applications look easy. With Teflon Seals, Case-Hardened Rods (50-54 Rockwell C), Patented "Shef" Tubing End Seals, and other exclusive *standard* features, these cylinders are practically damage-proof, are ultra-dependable under pressure and temperature extremes, and provide leakproof sealing with ALL hydraulic fluids. Built to *exceed* J. I. C. Specifications, these cylinders are achieving new highs in production and operating economies in thousands of plants. Two great lines: Power-Packed Model H for 3000-5000 psi and Job-Rated Model J for 500-2500 psi. All bores, strokes and mounting styles. Big "Stock" selection for immediate shipment at substantial savings.

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MILLER FLUID POWER

DIVISION OF FLICK-REEDY CORPORATION

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AIR AND HYDRAULIC CYLINDERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS • BOOSTERS

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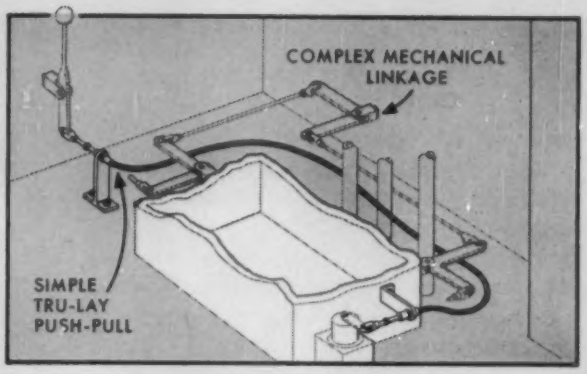
• If your products involve remote control—electrical, hydraulic, pneumatic or direct—TRU-LAY PUSH-PULL FLEXIBLE CONTROLS can help solve your design problems. They provide positive remote control over long or short distances—up to 150 feet from the control point. Because they operate while flexing, they can snake around obstructions. They will not buckle. They are ruggedly constructed, easily installed and operated, sealed against dirt and moisture, and will handle jobs with as much as 1,000 lbs. input. PUSH-PULL CONTROLS are simple, have but one moving part, are noiseless, and give a lifetime of accuracy. Mechanical linkages, on the other hand, are complex. Unlike PUSH-PULL CONTROLS, they are made of many parts, wear at many points, and produce increased backlash, lost accuracy, and vibration rattles.



Sizes and Operating Heads to Fit Your Design

Control Dimension	Minimum Recommended Radius in Inches	Maximum Input Load in Pounds (Dependent on Travel)
3/32"	2	30
1/8"	3	65-125
3/16"	5	115-175
1/4"	6	300-600
5/16"	8	700-1,000

Heavy Duty • For use where rugged duty prevails, but where operation must be smooth and accurate. Meets all requirements for dependability and life.

Light Duty • Gives smooth, accurate and dependable performance at low cost. Available with your choice of several types of knobs.

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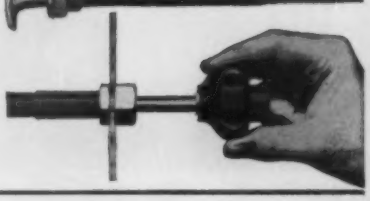

PUSH-PULL DATA FILE shows how to simplify, improve design

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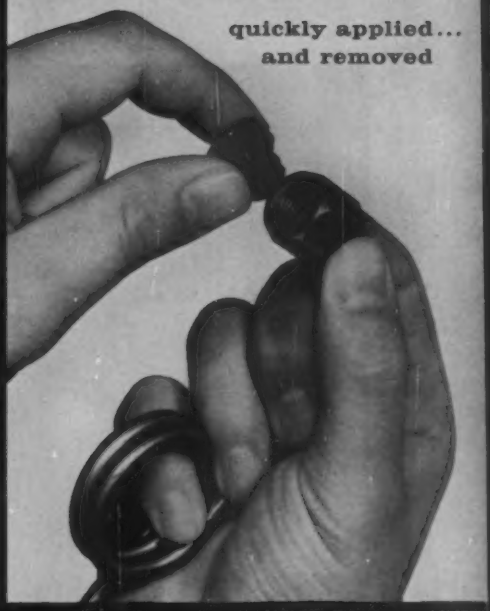

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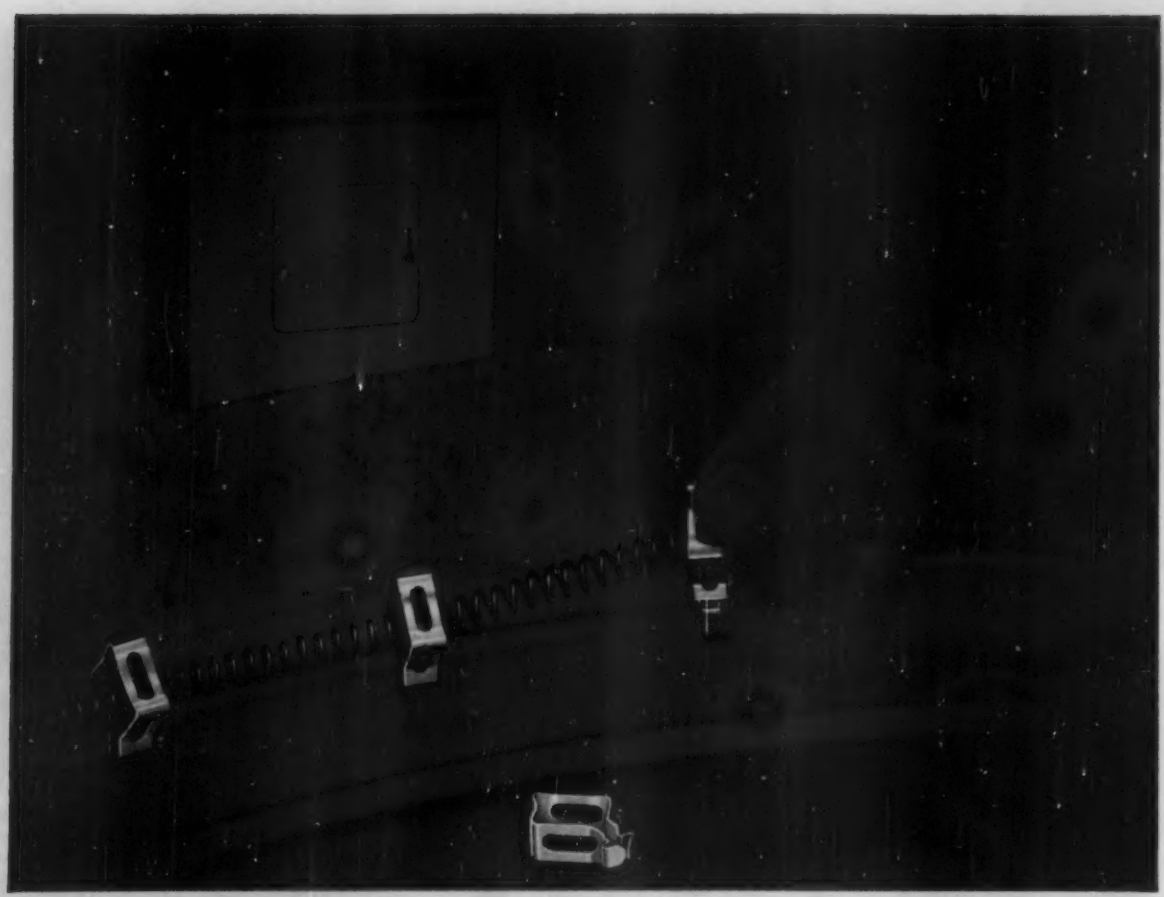

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PRODUCT ENGINEERING HORIZONS

July 18, 1960

MANUAL OF FAILURES

A few weeks ago, Warner & Swasey celebrated its 80th anniversary. Walter K. Bailey, president, presented Myron S. Curtis, engineering v-p, a 20-year service pin with these words: "The first lathe Myron designed for us, we turned down. We didn't like it. But some of the things we learned from it we put into our next design. They're still in the new designs." In plain English, W&S learned something from failure.

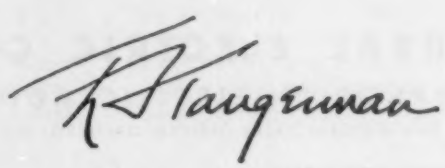
This reminded me of an ASME Oil & Gas Power session more than 20 years ago, at which three sales engineers each described his new diesel. Each was a perfect design, of course. Then the first discussor got up and began: "I would like to congratulate the authors of these three papers because they arrived at correct answers without the failures we had. Our first engine kept breaking connecting rods. In the second, we fixed that, but it blew off the cylinder head. In the third. . ." When the meeting ended, where did the engineers congregate? With the fellow engineer who also had failures—and learned from them.

A chief engineer was showing me a numerically controlled machine tool of rather radical design. "When we installed it, we had trouble with the hydraulic system. The maker fixed it. Then we had trouble with accuracy. The maker fixed that too. We expected troubles with a new machine, but the maker has the engineering experience to fix them."

These are typical; every engineer knows of similar cases. Yet an endless number of companies will never admit failure; they try to hide their mistakes because "they're bad for sales." The philosophy is that of a child who refuses to admit his mistakes for fear of punishment. When he's found out—and he always is—the punishment is more severe, unless his parents are inept. Whether it's a child or a company, the word on mistakes will get around, may be distorted or misinterpreted, with worse results than an honest confession.

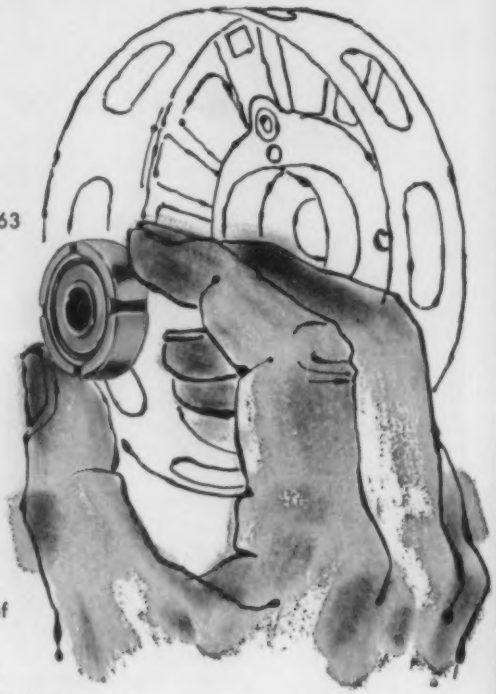
Studies in reliability (see PE—May 16 '60—p.65) are bringing forth a literature of failure that is avoiding similar mistakes on subsequent designs. Says M. P. O'Brien, dean emeritus of engineering at the University of California—Berkeley: "This was a large gap in engineering data. I hope this information can be expanded to a treatment of failure for any reason, not limited to physical failure. Companies and individuals are understandably diffident about explaining why projects fail, but the engineering profession needs to know in order to avoid repetitions in future designs. Isn't it time for a 'clinic' covering the pathology of design?"

Well, isn't it?



New Motors by **UNIVERSAL** introduce new free-aligning ball bearing assembly*

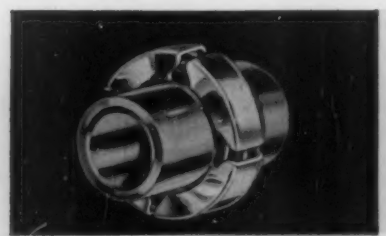
. . . utilizing only the shaft for alignment, the new Universal Ball Bearing Assembly provides:
. . . reduced noise level in ball bearing motors . . .
. . . easier starting regardless of load . . .
. . . elimination of pre-loaded bearings due to misalignment.



Two new UNIVERSAL ELECTRIC motors, Type 523 (4 pole) and Type 563 (6 pole) incorporate an entirely new ball bearing assembly design. The new ball bearing assembly is resiliently suspended in a neoprene collar with the axis of support in the center of the bearing. The bearing is thus inherently in balance and can adjust to any shaft misalignment 100% of the time utilizing only the shaft itself for alignment. This new design requires no pressure to retain the bearing in its position and the bearing cannot be forced from its seat regardless of the amount or type of load placed on the shaft.

Advantages of the UNIVERSAL ELECTRIC ball bearing design are (1) reduced noise level, (2) permanent cushioned end play, (3) easier starting, (4) elimination of snap rings, shoulders and undercuts thus providing a stronger motor shaft and (5) elimination of preloaded bearings due to misalignment thus resulting in a free running motor with a longer motor life. UNIVERSAL offers the only ball bearing shaded pole motors on the market that can make all of these claims.

*Pat. applied for



Universal Bearings*

Universal Free-Aligning sleeve-type Bearings eliminate fractional HP motor bearing problems due to misalignment. Like the new ball bearing assembly, this revolutionary bearing is inherently in balance and can adjust to any shaft misalignment 100% of the time under any load condition.

UNIVERSAL Electric Motors type 523 and type 563 with the new ball bearing assembly, offer the perfect flat speed torque curve necessary for critical air moving or recorder applications. In addition to these 2 new motors, UNIVERSAL ELECTRIC also is making a new 6 pole sleeve bearing motor Type 63 as well as the standard 4 pole, Type 23. These motors offer maximum performance and efficiency for kitchen ventilators, unit heaters, evaporative coolers, condenser fans, refrigerated cabinets, etc.

Write for complete specifications on your requirements.

55

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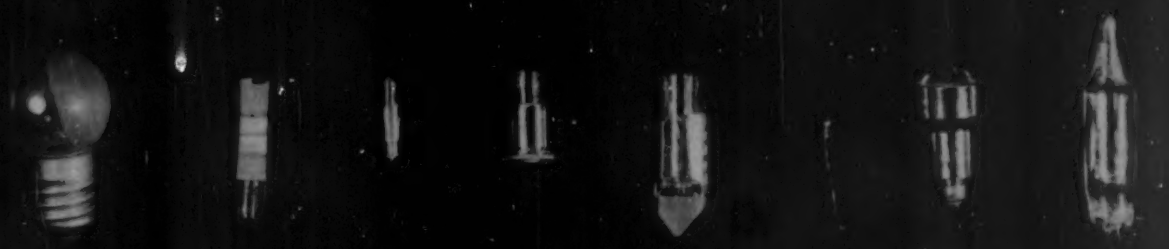


Straight-filament, semifrosted optical bulb | Computer lamp | "Grain of wheat" inspection bulb | Experimental carbon-filament lamp | Slide-based panel lamp | Micro-miniature bulb | Lens-tipped bulb | Circuit breaker with indicating light

Samples in photograph above from Herzog Miniature Lamp Works and Sylvania Electric Products

How to select MINIATURE LAMPS

When space won't allow a standard 120-v lamp—6 watts or larger—you may have to turn to the little fellows. And with them may come special design problems. Here are the compromises you face and characteristics you'll want to specify.

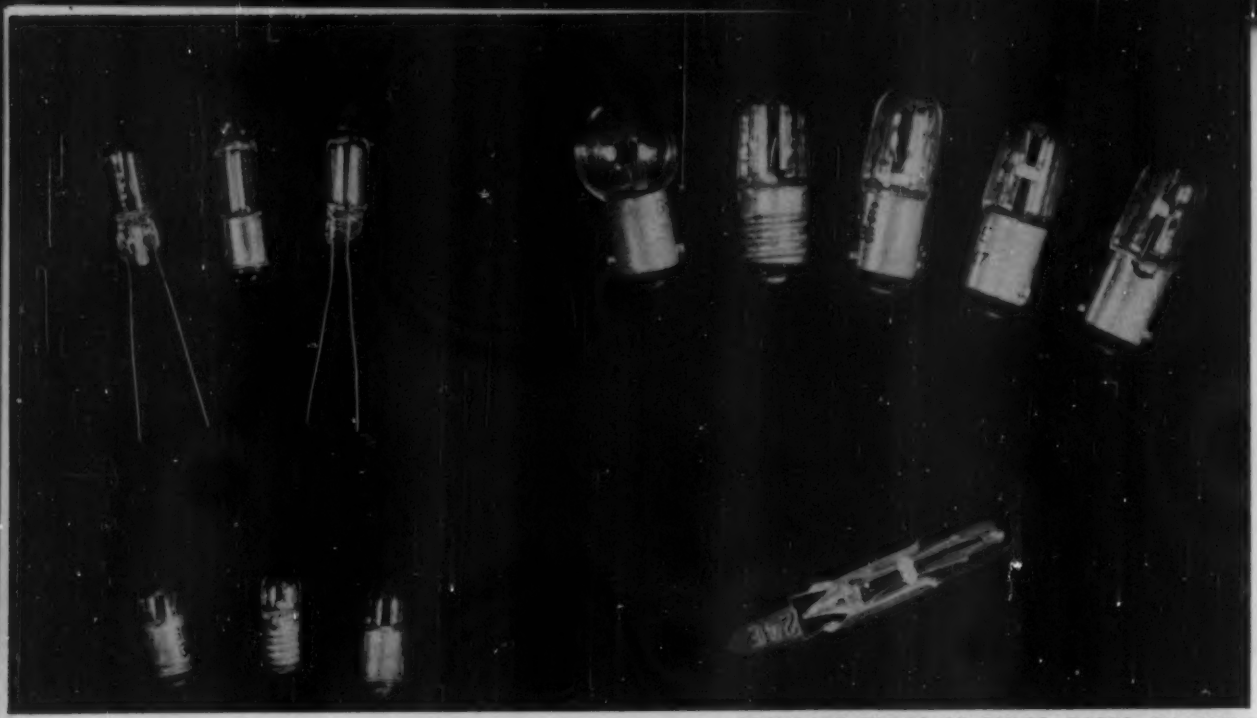
ANNESTA R GARDNER, *associate editor*

The best advice on when to use subminiature lamps—and it comes straight from the manufacturers—is this: Never, if they can be avoided.

But when space is not available for a larger lamp, those under ½ in. diameter may become necessary. This, despite the fact that the miniatures are, in general, more expensive and less efficient than standard types, and they may be shorter lived. In other words, the miniatures—particularly those under ¼ in.—will require design compromises, special power sources, and often call for adapter devices.

The factors in selecting miniature lamps are many: heat, light intensity, operating voltages, power drain (especially when transistorized circuits are used), optical qualities, life, and reliability. But, with good design procedures and new lamp types, light output can be doubled or tripled, lamp life prolonged, and overheating avoided. Few of these new lamps are catalog items yet, but many are available on a commercial basis. For example:

- GE recently introduced a much-improved, wedge-base, miniature neon lamp.
- Drake Manufacturing has brought out a replaceable-lamp indicator-light assembly that occupies barely ¼ cu in. of space and can be mounted in a $\frac{7}{16}$-in. hole. The lamps themselves have ¼-in. bulbs $\frac{5}{8}$ in. long.
- Signal-Stat has new lamp assemblies with shock-isolated sockets, specifically designed for automotive use.



STANDARD TYPES OF BULBS, BASES, FILAMENTS: At upper left—three neon lamps; upper right—five incandescent lamps, illustrating globular and straight-sided bulbs, screw and bayonet base, and light and heavy filaments; the one in the center of this group is the highest voltage available—55 v—in its size and type; Lower left—the smallest standard incandescent bulbs for 28-v operation, illustrating screw, grooved, and flanged bases. Lower right: telephone lamp for panel mounting. All samples shown here are from GE.

• A new subminiature neon lamp assembly from Circon Corp has an integral current-control unit that eliminates the need for a series resistor or external ballast. Power consumption is $\frac{1}{10}$ watt at 1 milliamp, and life expectancy is in excess of 25,000 hr.

• Industrial Devices Inc is readying new rectangular lights and also several new types of small-diameter pilot assemblies.

• Sylvania has miniature circuit breakers with built-in indicating lamp elements, as well as the tiny lamps pictured on p 57; Tung-Sol has new long-life miniatures; and Westinghouse has electroluminiscent panels in less-than-an-inch size.

• Master Specialties has a new indicator-light system that allows miniature incandescent bulbs to be operated directly from 115-v circuits without external transformers.

Furthermore, recent years have seen the development of electroluminiscent panels (*PE—Sep 15 '58, p 74*) that can illuminate instrument dials, and in some cases, can replace a bank of miniature lamps.

Coming up—but not yet available, except on a sample basis—are square lamps, neon lamps with higher light output (though still below the incandescent level), ultra-high-intensity xenon lamps, and new miniature carbon-filament lamps that promise to be more rugged than tungsten types that are now available.

Know their limitations

The first step in selecting a minature lamp (or any lamp, for that matter) is to recognize what it can and cannot do. And one thing the very small lamps cannot do is attract attention—particularly from a distance.

Where lamps must strongly attract attention, just about the smallest practical size is the 120 v 6-watt bulb—the size of the standard Christmas tree light. This is considered a "large" lamp; but it's barely $\frac{3}{4}$ in. dia and only $1\frac{3}{4}$ in. long. However, its light output is far greater than that of the largest "miniature."

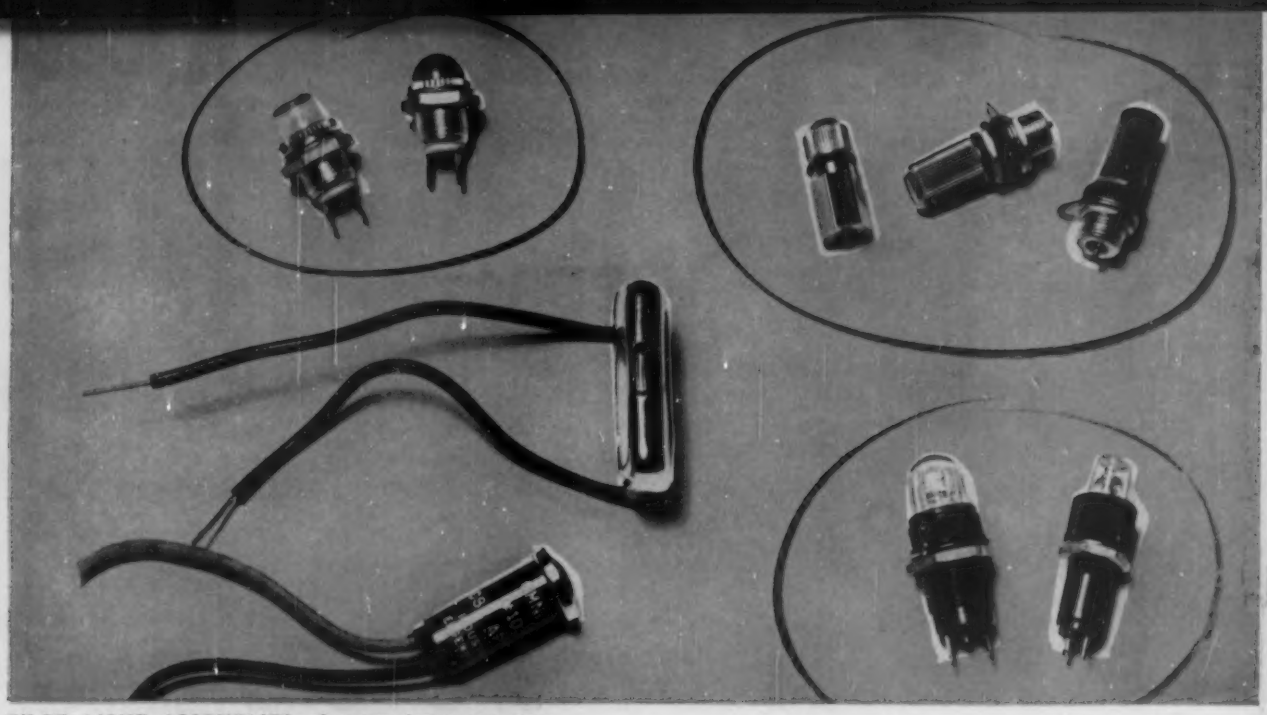
Even with these larger lamps, it may be desirable to use two bulbs instead of one to provide increased light output, and also assure that there will be at least some indication of trouble when one light fails.

But, if panel space is limited, and a small amount of light will do the job, a miniature lamp is probably indicated, and lamp choice will depend on:

- Power source—line or battery
- Limitation on current and voltage
- Optical qualities
- Light intensity needed
- Lamp life
- Panel area and depth available for the lamp and lamp assembly
- Cost of bulb and pilot light assembly.

Catalogs help—a little

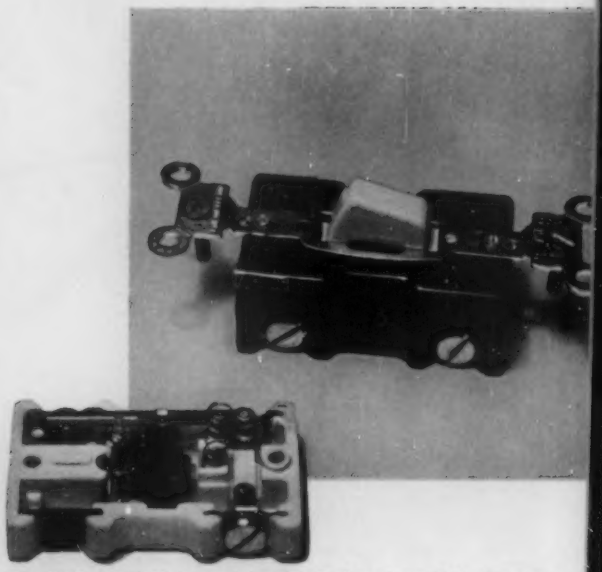
To guide choice of the proper lamp, some excellent catalogs are available. But, in the lamp business, catalogs are only a rough guide. Often they include lamps that are uneconomical to make and use—and omit new types that may be just the answer to your problem. Of the



PILOT LIGHT ASSEMBLIES of many types are now available commercially. At upper left are newest, smallest ones made by Drake. At upper right, screw and swage-base types by Circon. Lower left: two "Omni-glow" panel lights designed by Industrial Devices Inc for operation at 75 v to 250 v, ac or dc. Lower right: typical Dialight pilot light assemblies, made with many types of caps.

For this requirement...	*Your choice...*
Operation at line voltages	Neon and electroluminescent lamps are best. (Most incandescent lamps for operation at 120 v are quite large.) Base types for lamps operating at line voltages are subject to UL regulations. They should be checked before selection is made.
Low-voltage circuits (below 28 v)	Incandescent or electroluminescent lamps. Neon cannot generally be used for applications of this type.
Transistor power supply	New, low-power (10 v-15 ma) incandescent lamps or neon lamps, or electroluminescent panels; light output is low and a converter will be required for a neon lamp. Neon and electroluminescent color range is limited.
Battery power supply	High-intensity, high-efficiency, low-power incandescent lamps. Here, lamp life is relatively unimportant because even a short-lived lamp will likely outlast the battery. Use highest current and lowest voltage for increased ruggedness.
Long life and high reliability	Neon or electroluminescent. If incandescent lamps must be used, operate below rated voltage. Use two lamps in parallel where possible.
Heat-shock and vibration	Low-voltage incandescent lamps with squat filaments; neon lamps; bayonet bases.
High-intensity light	Standard incandescent lamps, the larger the better. For highest intensity from miniature lamps, use focusing lenses or lens-tipped bulbs, aluminized bulbs, and diffusers and reflectors.

MINIATURE LAMP AND PHOTOCELL are key elements in new infrared scanner made by Farmer Electric Products. Light is projected out through prefocused lens. Passing objects reflect it back, activating the photocell. Lamp life is increased from 6000 hr to 60,000 hr by reducing voltage from 6 to 5 v. This decreases scanning range by about 1/3, but increased lamp life makes it worthwhile.



TO ADD LIGHT to previously designed switch, Harvey Hubbell engineers redesigned base and interior of operating lever to provide space for lamp. Small neon lamp operates on standard voltages with low heat emission. Switch button lever itself is made of heat-resistant nylon and the case is molded of phenolic plastic.

standard bulb shapes, base types and operating characteristics, some combinations are far more costly than others and some are impractical or impossible. For instance, "telephone" lamps are made only with slide bases. Screw candelabra bases cannot be put on.

Most catalogs don't show prices, either (though separate price sheets are available)—and the prices even of "standard" subminiatures can be pretty high. Flashlight lamps usually cost less than 3¢ in quantity; but the cheapest subminiature lamp is 20¢ to 30¢; and the tiny "grain of wheat" lamp runs from $1.35 to $2.50 each in lots of 1000. This is a good reason for considering the standard cataloged "auto" and "toy train" lamps for applications requiring considerable light.

There are other problems in using miniature lamps, too, that don't show up in the catalogs. Some of the smaller lamps designed for relatively high voltages (28 v instead of 6 v) are so tiny and the filaments so big that the slightest vibration may short-circuit them. Some have even been known to short during shipment.

Miniature lamps designed for lower voltages (6 to 12 v) are not as likely to do this; but the desire to save space with them often results in such tight crowding on display panels that shorting of the panel circuit becomes a problem.

Another caution that comes from both manufacturers and users:

If at all possible, avoid mounting a miniature lamp on a pushbutton. They just are not rugged enough. If possible, mount them separately and use acrylic plastic to pipe light to the button, or some similar solution. If combined mounting is unavailable, use the more rugged neon lamps; but remember that light output will be low.

10 points to remember

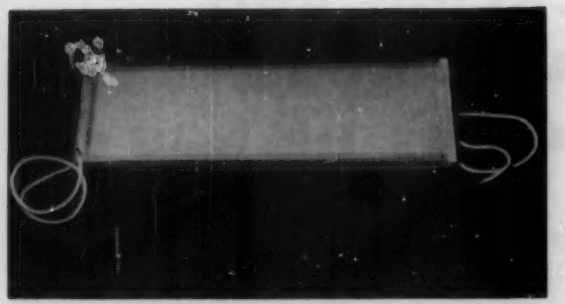
Summing up, the important guideposts to design for miniature lamps are:

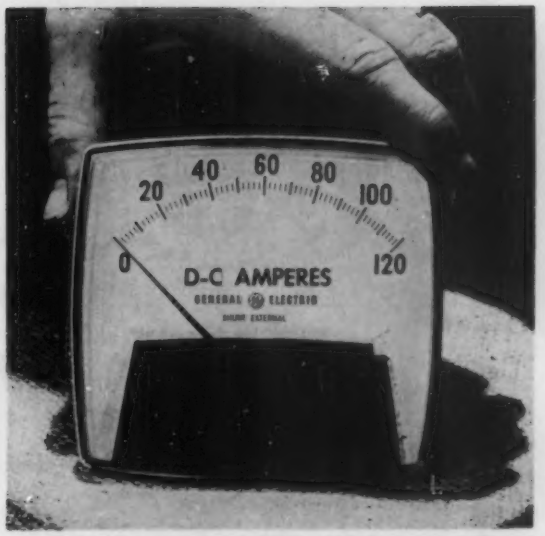
1. Make sure there is enough space—not just for the lamp, but for the assembly. In general, that means not less than ⅜ in. for neon, 1 in. for 120-v incandescent. The lamp itself is usually the smallest part of the lamp installation. It's often much better and safer to specify a pilot or indicator assembly than a specific lamp.

2. Recognize that many mass-produced lamps are not held to close size tolerances. Do not base design on a single sample. It is a lot cheaper in most cases to provide a little room that allows for size variations than to buy lamps especially selected for a limited size range.

3. Specify optical qualities carefully when special optical properties are needed. Seismograph lamps, pyrometer lamps, optical comparators and projectors, and eye instruments may need a line of light or a controlled color. To avoid distorted filament images, it may be necessary to specify a lamp that is accurately focused to 0.010 in.

4. Consider maintenance problems. For vending machines, and similar equipment, it costs $5 to send a man out to replace a lamp. Much better to pay an extra 10¢ for a longer-lived lamp, or add voltage or current stabilization if lamp replacement may be costly.





ELECTROLUMINESCENT PANELS, provided with suitable numbers or markings, may take the place of entire battery of miniature lamps. They're available in sizes from 2 by 2 in. over-all (with lighted area about ½ in. less on each dimension); will operate at standard voltages and above; provide cool, long-lasting light source. Pictured here at left is basic panel, marketed by Westinghouse; and, above, prototype model of new meter being readied for market by General Electric in which an electroluminescent panel is to be used.

5. Recognize the compromise between life and efficiency that must be made with all incandescent lamps.

6. Study heating problems—and solutions. For instance, with incandescent lamps, even temperatures well below the softening point of the glass may cause blackening of the bulb owing to evolution of water vapor. Plastic buttons or caps may soften at relatively low operating temperatures unless provision is made for heat dissipation. Remember, wattage indicates heat. In small incandescent lamps, watt/size ratio is high, and it is very hard to measure heat—and know exactly how much you'll get.

7. Consider lamp life carefully. Figures on lamp life represent average life, at or below rated voltage. Of any given group of lamps, at least 5% will burn out in less than a third of the rated time. Others will last far longer than the rating would indicate.

8. Remember that miniature lamps are primarily *indicators*. Many are not bright enough to be seen from any distance. Check visibility at various angles, too, where side-line visibility may be important.

9. Use catalogs as a guide; but remember they often show what *might* be made; not necessarily what *is* made. Too, they may fail to show new, improved types, and give little or no information on dimensional tolerances.

10. Keep up with new developments. They're coming along fast. Many of the types labeled "experimental" right now will be commercial before year's end—and at the current rate of development there will be a whole new group out on test when these are ready for production.

Which Kind of Lamp?

Consider neon lamps where

- operation is at line voltages
- red or yellow color is acceptable
- long life is important
- light output need not be great
- shock or vibration call for sturdy construction
- heat must be held to a minimum
- less than 1-in. clearance is available

Consider electroluminescent lamps where

- long life is important
- a single electroluminescent panel may substitute for a whole row or line of separate lamps
- heat cannot be tolerated
- low light intensity is satisfactory
- blue-green color is acceptable
- standard line voltages are available

Use incandescent lamps when

- Light output is important and light must be focused
- special optical characteristics—such as color and line image—are important
- at least 1-in. mounting clearance is available
- heat will not pose serious problems

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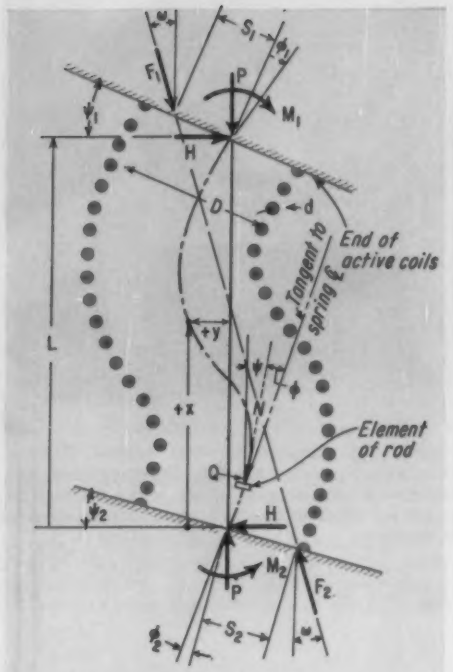


SPRING BUCKLING under nonparallel compression

how to predict

BUCKLING AND UNSEATING OF COIL SPRINGS

Here are the latest equations for predicting what happens when a coil spring is compressed between parallel or nonparallel plates. The theory is confirmed by test results, and a sample problem shows how to put the equations to work.

T M LOWERY, *project engineer*
Chrysler Corporation

A coil spring may buckle under compression if the ratio of its free length to coil diameter is large, or may unseat if the two compressing plates are nonparallel. The overly long spring remains straight until buckling occurs; but with nonparallel compression there is always a certain amount of lateral deflection which may cause the spring to unseat itself (lifting or sliding off its seat). This can produce a knocking sound with each operating cycle.

Nonparallel compression is quite common with designs that employ coil springs to resist the motion of a pivoting link. The problem of a coil spring unseating arose in connection with designing an automotive suspension system; to solve it, a new set of design equations was developed from which it is now possible to predict:

For parallel compression:

- When does a spring buckle?

For nonparallel compression:

- When does a spring unseat?
- How much clamping force is needed to prevent unseating?
- How much side clearance is needed?
- What is the true resisting force and line of action?

Predictions based on the design equations compare favorably with results from limited tests conducted at Chrysler Corporation's laboratories. The equations, sample problem and test results are given below.

THE DESIGN EQUATIONS

For a coil spring to be in equilibrium when compressed between two nonparallel plates, the forces on the plates or seats must be equal, opposite and colinear (F_1 and F_2 in illustration on previous page). These resulting forces are at a distance S_1 and S_2 from the spring centerline, measured along the spring seats.

Forces F_1 and F_2 can be replaced by a combination of moments, M_1 and M_2, and a set of horizontal and vertical forces, P and H, acting on the spring at its centerline.

The equations developed below are based on previous work by J. A. Haringx (see "On Highly Compressible Helical Springs and Rubber Rods and Their Applications for Vibration-free Mountings," Philips Research Reports, Dec '48, p 401-449). They assume a relatively close-coiled helical spring with wire of circular cross-section. Spring weight, seat friction and end-coil effects are not taken into consideration—however, tests indicate that the equations give fairly accurate results.

By assuming the spring acts as an elastic rod, the moment M, normal force N, and shear force Q at any point (x, y) are:

$$M = Py + H(L - x) + M_1$$
$$N = P\cos\psi - H\sin\psi$$
$$Q = P\sin\psi + H\cos\psi$$

For small angles

$$Q \approx P\psi + H$$
$$N \approx P - H\psi$$

In order to consider the spring behaving like an elastic rod, its rigidity in bending, shear and compression must equal these values:

Load	Spring Rigidity	Similar Rigidity For a Beam
Moment, M:	$\alpha = \frac{Ld^4}{n}\left(\frac{E}{32D\left(1+\frac{E}{2G}\right)}\right)$	EI
Shear, Q:	$\beta = \frac{Ld^4}{n}\left(\frac{E}{8D^3}\right)$	AG/K
Compression, N:	$\gamma = \frac{Ld^4}{n}\left(\frac{G}{8D^3}\right)$	AE

Thus $$\frac{d\psi}{dx} \approx \frac{M}{\alpha} = \frac{Py + H(L-x) + M_1}{\alpha}$$

and $$\phi = \frac{Q}{\beta} \approx \frac{P\psi}{\beta} + \frac{H}{\beta}$$

Slope of the deflection curve is equal to the sum of the slopes due to bending and shear, or

$$-\frac{dy}{dx} = \psi + \phi = \left(1 + \frac{P}{\beta}\right)\psi + \frac{H}{\beta}$$

Differentiating the above equation gives

$$\frac{d^2y}{dx^2} + \frac{P}{\alpha}\left(1 + \frac{P}{\beta}\right)y = -\left(1 + \frac{P}{\beta}\right)\left[\frac{H(L-x) + M_1}{\alpha}\right]$$

Letting

$$q^2 = \frac{P}{\alpha}\left(1 + \frac{P}{\beta}\right)$$

SYMBOLS

A	= cross-sectional area of equivalent beam
d	= wire diameter
D	= mean coil diameter
E	= Young's modulus
F	= resultant force
G	= shear modulus
H	= horizontal reaction force
K	= rigidity constant (see Timoshenko, *Strength of Materials*, Vol I, p 170).
L_o	= free length of spring (active portion only)
L	= compressed length (active portion only)
M	= moment
n	= number of active coils
N	= force normal to cross-section of an equivalent elastic rod
P	= vertical reaction force
q	= buckling factor (in.$^{-1}$)
Q	= shear force
S	= locating distance of resultant force
x, y	= coordinates of spring centerline
α, β, γ	= rigidity constants
ω	= angle that resultant force F makes with P
ϕ	= slope of spring centerline caused by shear alone
ψ_1, ψ_2	= angles of ends of spring, or seat angles when spring is seated
ψ	= angle of spring centerline caused by bending alone. At end conditions, ψ equals either ψ_1 or ψ_2.
θ	= angle of pivot link

and solving, gives

$$y = C_1\sin qx + C_2\cos qx - \frac{H(L-x) + M_1}{P}$$

Using the boundary conditions $y = 0$ at $x = 0$, and $y = 0$ at $x = L$, gives:

$$C_1 = \frac{M_1}{P\sin qL} - \frac{LH + M_1}{P\tan qL}; C_2 = \frac{LH + M_1}{P}$$

From which is obtained . . .

The equation which defines the spring shape:

$$y = \frac{1}{P}\left[M_1(\tan(qL/2)\sin qx + \cos qx - 1) + HL\left(-\frac{\sin qx}{\tan qL} + \cos qx + \frac{x}{L} - 1\right)\right]$$

Differentiating above equation gives . . .

The seating-angle equation:

$$\psi = -\frac{32nD\left(1 + \frac{E}{2G}\right)}{d^4LEq}\left[M_1\left(\tan\frac{qL}{2}\cos qx - \sin qx\right) + HL\left(-\frac{\cos qx}{\tan qL} - \sin qx\right) - \frac{H}{P}\right]$$

Other equations of importance can now be obtained.

The buckling factor:

$$q = \frac{1}{D}\sqrt{\left[\left(\frac{2G}{E}\right)^2 + \frac{2G}{E}\right]\left[\frac{E}{G}\left(\frac{L_o}{L} - 1\right) + \left(\frac{L_o}{L} - 1\right)^2\right]}$$

(continued on page 64)

The equations for horizontal and vertical forces:

$$P = \frac{G\,d^4\,(L_o - L)}{8\,n\,D^3}$$

$$H = \frac{P\,(\psi_1 + \psi_2)}{\left(\frac{4\,G}{E} + 2\right)\left(\frac{L_o - L}{qD^2 \tan\,(qL/2)}\right) - 2}$$

The resisting moments:

$$M_1 = \frac{E\,G\,q\,L\,d^4}{16\,(2G + E)\,(nD)\tan\,(qL/2)}\left\{\psi_1 + \frac{H}{P}\left[1 - \left(\frac{4\,G}{E} + 2\right)\left(\frac{L_o - L}{qD^2 \sin\,qL}\right)\right]\right\}$$

$$M_2 = M_1 + HL$$

From a summation of the moments acting on the spring, M_1, M_2, L and P can be resolved into forces F_1 and F_2 acting at an angle ω with the line of centers and located at distances S_1 and S_2 from the spring centers at the upper and lower ends of the spring. Thus:

The equation for the resultant force

$$F_1 = F_2 = \sqrt{P^2 + H^2}$$

. . . acts at an angle

$$\omega = \tan^{-1}\,(H/P)$$

. . . at a distance

$$S_1 = \frac{-\,M_1}{\sqrt{P^2 + H^2}\cos\,(\psi_1 + \omega)}$$

. . . and at a distance

$$S_2 = \frac{M_1 + HL}{\sqrt{P^2 + H^2}\cos\,(\psi_2 + \omega)}$$

With parallel plates, buckling occurs when

$$qL = 2\pi$$

With nonparallel plates and with a spring whose ends are ground

. . . unseating occurs when

$$|S_1| \text{or} |S_2| > \frac{D + d}{2}$$

in other words, when the line of action of force F falls outside the line of contact of the spring.

For a spring with unground ends, unseating occurs when

$$|S_1| \text{or} |S_2| > \frac{D}{2}$$

EQUATIONS FOR STEEL SPRINGS

The equations can be simplified for steel springs by substituting the values E = 30 x 10^6 psi and G = 11.5 x 10^6 psi to give:

The buckling factor

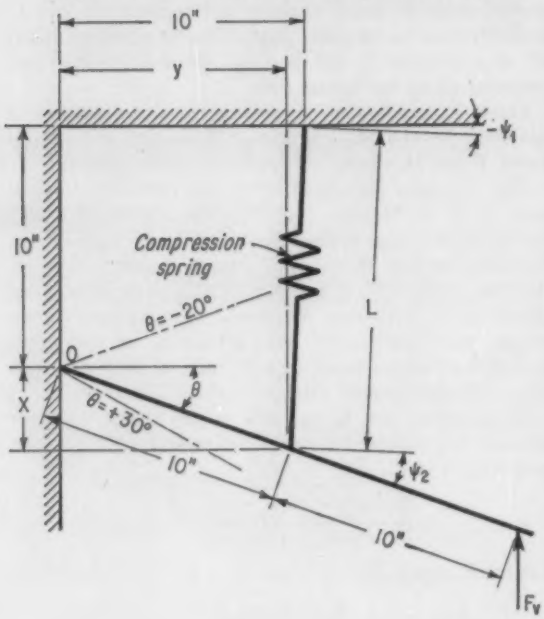
$$q = \frac{1.16}{D}\sqrt{\left(\frac{L_o}{L}\right)^2 + 0.61\left(\frac{L_o}{L}\right) - 1.61}$$

The two reaction forces

$$P = \frac{(1.44 \times 10^6)\,(d^4)\,(L_o - L)}{nD^3}$$

$$H = \frac{P\,(\psi_1 + \psi_2)}{\frac{3.53\,(L_o - L)}{qD^2 \tan\,(qL/2)} - 2}$$

Layout of Pivot Rod and Compression Spring



The resultant force acts at distances

$$S_1 = -\,\frac{0.282\,q\,L\,D^2}{\sqrt{1 + \left(\frac{H}{P}\right)^2}\,(L_o - L)\tan\,(qL/2)\cos\,(\psi_1 + \omega)\left[\psi_1 + \frac{H}{P}\left(1 - \frac{3.53\,(L_o - L)}{q\,D^2 \sin\,q\,L}\right)\right]}$$

$$S_2 = \frac{1}{\cos\,(\psi_2 + \omega)}\left[\frac{L\,H}{\sqrt{P^2 + H^2}} - S_1 \cos\,(\psi_1 + \omega)\right]$$

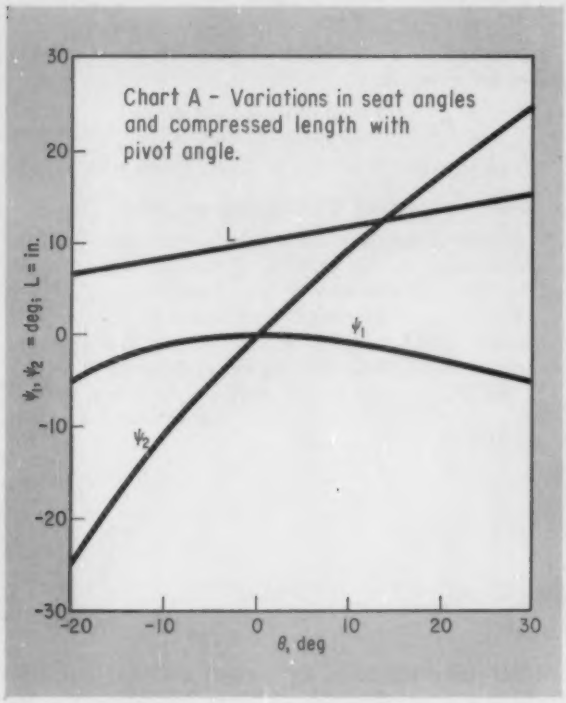
Calculations should be made at as many stages of compression as necessary, using the free and compressed lengths of the active portion of the spring for L_o and L_f respectively.

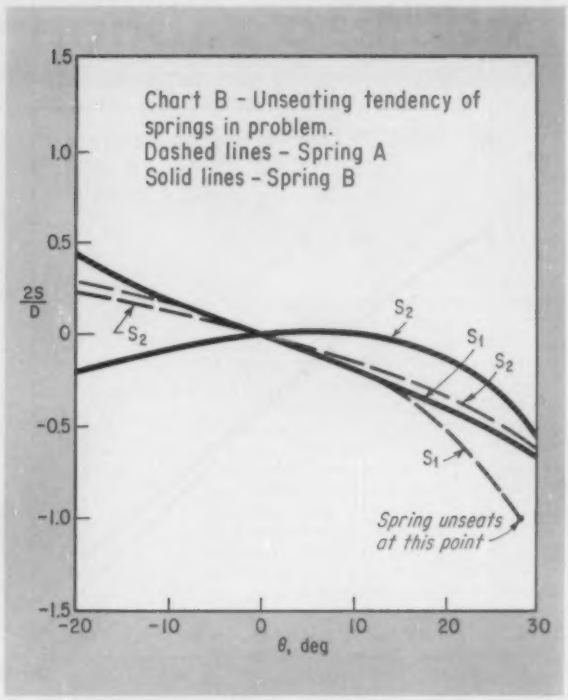
Angles ψ_1 and ψ_2 are at upper and lower ends of the spring and are the same as the seat angles if the spring is fully seated. When the spring is not fully seated the angle at which the spring becomes unseated must be used at the unseated end or ends.

SAMPLE PROBLEM—SPRING FOR A PIVOT MECHANISM

Given the system shown below in which the link swings through an angle measured 20° above and 30° below the horizontal, analyze the difference in performance between two coil springs with the same spring rate and free length but with these characteristics:

	Spring *A*	Spring *B*
Mean diameter, D	6 in.	4 in.
Wire diameter, d	0.315 in.	0.276 in.
Number of active coils, n	6.3	12.5
Active free length, L_o	18 in.	18 in.





From the above figure:

$$x = 10 \sin \theta,\ y = 10 \cos \theta$$

$$L = 10\sqrt{3 + 2(\sin \theta - \cos \theta)}$$

$$\psi_1 = -\tan^{-1}\left(\frac{1 - \cos \theta}{1 + \sin \theta}\right)$$

$$\theta = \psi_2 - \psi_1$$

$$\psi_2 = \theta + \psi_1$$

Typical calculations for spring A (when $\theta = +20°$):

$$L = 10\sqrt{3 + 2(\sin 20° - \cos 20°)} = 13.44 \text{ in.}$$

$$\psi_1 = -\tan^{-1}\left(\frac{1 - \cos \theta}{1 + \sin \theta}\right) = -2.57° = -0.0448 \text{ radians}$$

$$\psi_2 = 20 - 2.57 = 17.43° = 0.305 \text{ radians}$$

Variations in L, ψ_1 and ψ_2 for various angles θ are shown in Chart A, above.

The buckling factor is

$$q = \frac{1.16}{6}\sqrt{\left(\frac{18}{13.44}\right)^2 + 0.61\left(\frac{18}{13.44}\right) - 1.61} = 0.194 \text{ in.}^{-1}$$

The reaction forces are

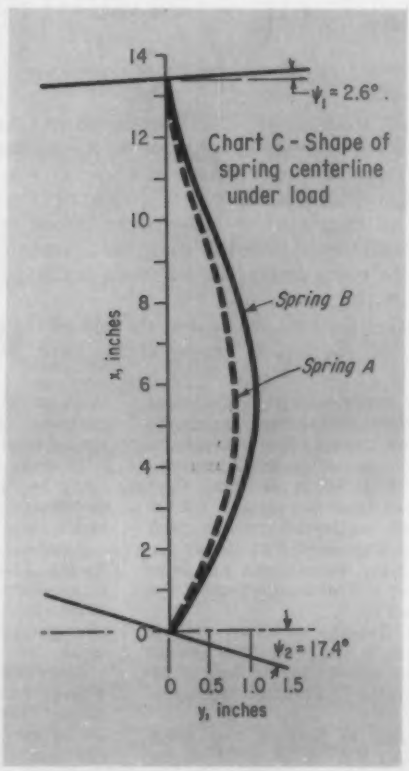
$$P = \frac{(1.44 \times 10^6)(0.315)^4 (18 - 13.44)}{(6.3)(6)^3} = 47.4 \text{ lb}$$

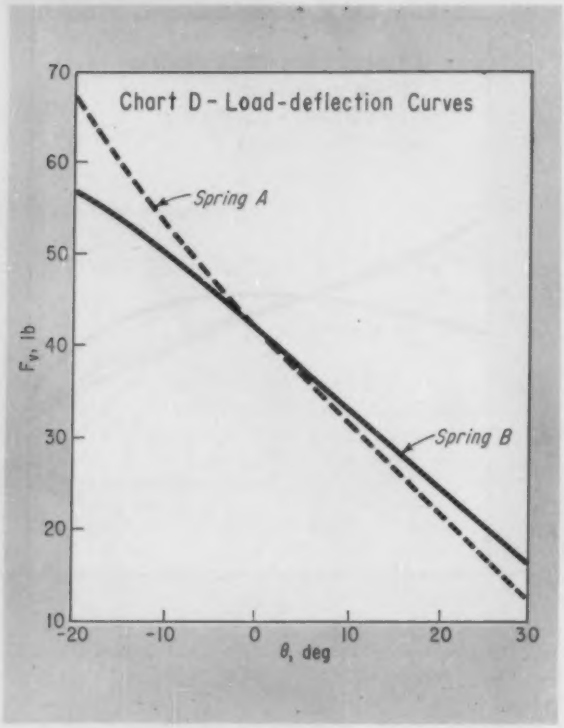
$$H = \frac{47.4(-0.0448 + 0.305)}{\dfrac{3.53(18 - 13.44)}{0.194(6)^3 \tan\left(\dfrac{2.61}{2}\right)} - 2} = -8.99 \text{ lb}$$

Line of action is at

$$\omega = \tan^{-1}(-0.1895) = -0.1873 \text{ radians}$$

continued on page 66





$$S_1 = \frac{0.282\,(2.61)\,(6)^2}{\sqrt{1 + (-.1895)^2\,(4.56)}\,\tan 1.3\cos(0.232)}\left[-0.0448 - 0.1895\left(1 - \frac{3.53\,(4.56)}{(0.194)\,(6)^2 \sin 2.61}\right)\right] =$$

1.005 in.

$S_2 = -1.54$ in.

Variations in $2S_1/D$ and $2S_2/D$ are shown in Chart B for both springs at various angles of θ. An unclamped spring with unground ends will unseat when $2S/D = \pm 1$, thus spring A will unseat when $\theta = +28°$.

Deflections from the line between the centers of the spring seats can be calculated by using the equation for y. Shapes of the spring center lines are shown in Chart C for $\theta = +20°$.

The vertical force F_v, required at the end of the pivot link to deflect the link to various degrees of θ, can be determined by a summation of moments about point o, thus for spring A:

$$F_v = \frac{(10 + S_2)\,(P\cos\psi_2 - H\sin\psi_2)}{(10 + 10)\cos\theta}$$

This equation is plotted in Chart D for both springs.

THEORY CONFIRMED BY TESTS

A series of tests were made using a steel spring with the specifications: $L_o = 14.2$ in., $d = 0.283$ in., $n = 24$, $D = 2.18$ in., squared and ground ends.

The spring was mounted horizontally in a fixture with movable spring seats. Lateral deflections and unseating angles were measured with the spring compressed to 10.5, 12 and 13.5 in. with various angles at the spring seats. A comparison of test results and calculations (shown in parenthesis) is shown below.

L	ψ_1	ψ_2	Deflection at $x = L/2$	Unseating angle, ψ_2
10.5 in.	+5°	+5°		22° (23°)
10.5	+5	−5	1.17 (1.30) in.	15 (13)
12.0	+10	+10		28 (32)
12.0	+10	−10	1.00 (1.08)	29 (29)
13.5	+5	+5		11 (8)
13.5	+5	−5	0.30 (0.36)	16 (16)

The tabulated values are averages and were repeatable within a range of about ±0.05 in. for deflections, and ±2° for unseating angles. Reversing the ends of the spring in the fixture caused no detectable difference in the results.

The spring in the test fixture was subjected to two effects which were not considered in the analysis: eccentric loading caused by the end coils, and spring weight. Therefore the tests were conducted with the spring in a nearly horizontal position so that deflections from eccentric loading (in an upward direction) tend to balance the spring weight.

To determine whether the spring buckled at the theoretical value $qL = 2\pi$, the spring was compressed by tightening a rod connecting the two spring seats. When the spring was compressed 4.35 in., the center of the spring side-deflected enough to come into contact with the rod (a deflection of 0.67 in.). The theoretical amount of compression to buckle this spring is 4.7 inches.

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EDITOR'S NOTE—As most designers know, designing the best spring involves many factors. For example:

How Light a Spring for Absorbing Shock?, Feb 1 '60, p 49—You don't even have to know the spring's dimensions—these equations quickly find the lightest type needed to absorb impact of a mass. Dimensions can later be varied at will without affecting the weight analysis.

How to Design Multirate Helical Springs, Jan 20 '58, p 76—Two special methods for assembling springs in series to obtain multirate characteristics.

Your Guide to Springs that Store Energy Best, Nov 10 '58, p 71—Equations and tables that give definite comparisons among many materials and spring types.

29 Ways to Fasten Springs, Dec 21 '59, p 66—A rundown of ingenious attachments for extension, compression and torsion springs.

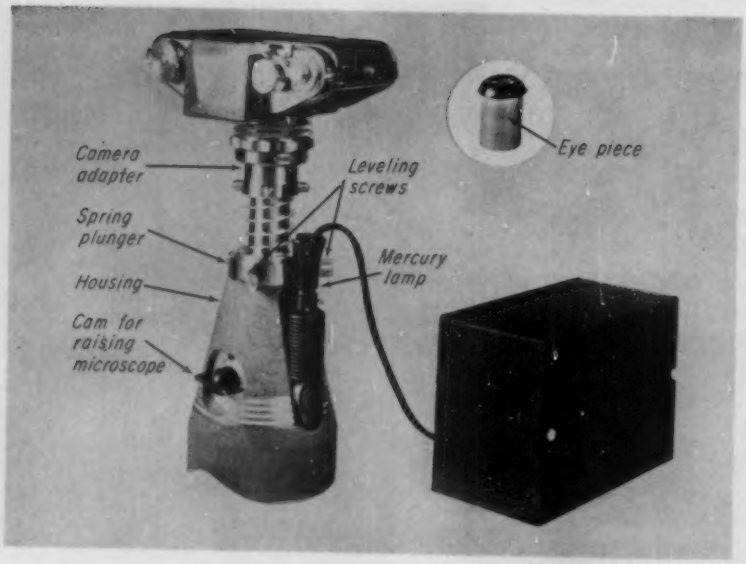
Reinforced Plastics for Better Springs, Nov 9 '59, p 74—Directionally reinforced epoxy laminates are more efficient than steel for many leaf-spring applications. Gives stress equations.

Glass-fiber Sleeve-springs for High Energy Absorption, Aug 17 '59, p 60—Latest development from research lab of world-famous gun manufacturer can handle five times as much kinetic energy from impact as can equivalent steel springs. Included are charts and equations giving stress, spring, and energy-absorption characteristics.

Saving Space with the Liquid Spring, Aug 17 '59, p 54—A single liquid spring can provide as much "springiness" as 30 coil springs of same length and diameter. Article tells why and how.

How Much Force to Deflect a Spring Sideways? Jan 5 '59, p 71—Formulas for force and stress when a load deflects a vertically loaded coil spring in a lateral direction.

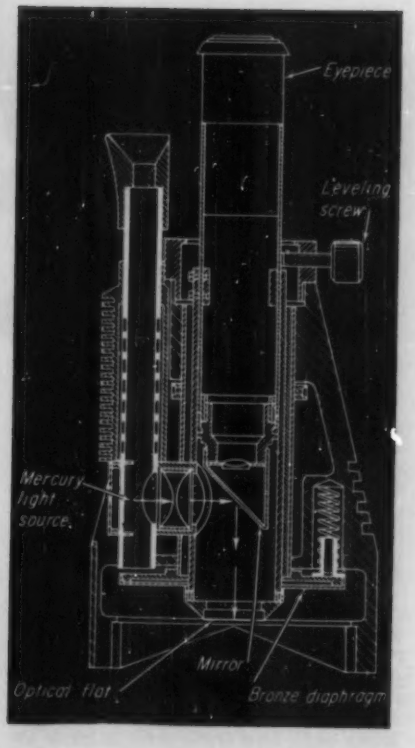
Surge Waves in Compression Springs, Aug '57, p 167—Article presents one of the most noteworthy advancements in spring design.



A SAMPLE IS STUDIED either through an eyepiece, or (as shown) a recording camera is attached to the interferometer. In eyepiece method, interferometer is placed on the sample to be checked, the optical tube is lowered, and the observer looks down. Eyepiece shows him a pattern of sharp black lines against a bright green background. From the configuration of the black lines, condition of the sample surface can be deduced and measurements made.

The black interference lines form a contour map of the surface being inspected. The distance between adjacent lines represents a height perpendicular to the sample of exactly 10.74 microin. (0.000,010.74 in.) This is a fundamental constant for the instrument fixed by the type of light source and is the scale from which all measurements are estimated. Thickness of the black line represents the roughness of surface.

Using the camera and measuring on film permits the maximum resolution of 1/10 microin. to be realized.

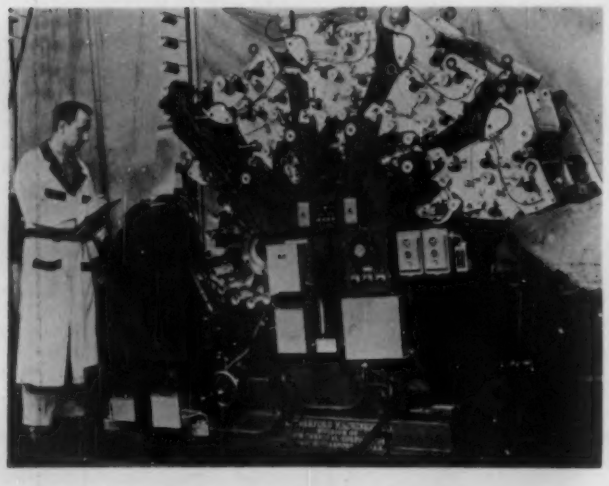


Portable Interferometer for Polished Surfaces

Optical method goes to the job to examine defects on highly polished surfaces. High resolution of the multibeam system reveals very fine details, makes measuring easier.

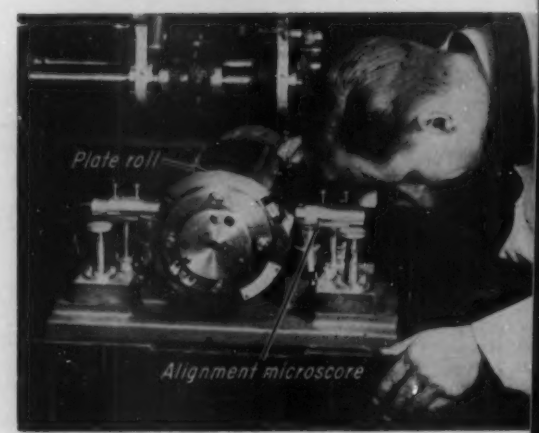
THE HOUSING of the interferometer is constructed of cast aluminum. It provides a steady base which stands firmly on a flat surface, and a V-cutout permits it to straddle cylindrical surfaces. Incorporated in the base casting are a microscope, mercury light source, and interference plate or optical flats. Lower end of the unit is suspended in a phosphor bronze diaphragm which prevents lateral motion but gives the necessary freedom for the optical flat to be adjusted to parallelism with the work by means of leveling screws. The leveling is accomplished by two leveling screws and a spring-loaded plunger at the upper end of the microscope. After passing through a condenser and green filter, the mercury light is reflected by a front surface mirror through the optical flat to the work surface. The microscope and the flat are raised and lowered to the work by a knob on the side of the instrument.

PS . . . Interferometer's range is from a few microin. down to 1/10 of a microin. The instrument has been called on to examine rolls used in producing aluminum foil, photographic film base and other web materials, for checking the finish and curvature of gyro pivots, finish of bearing balls, etc. Micromu Surface Interferometer is produced by L C Eichner Instruments, Clifton, NJ.



Speedy Printer Has Plug-in Colors

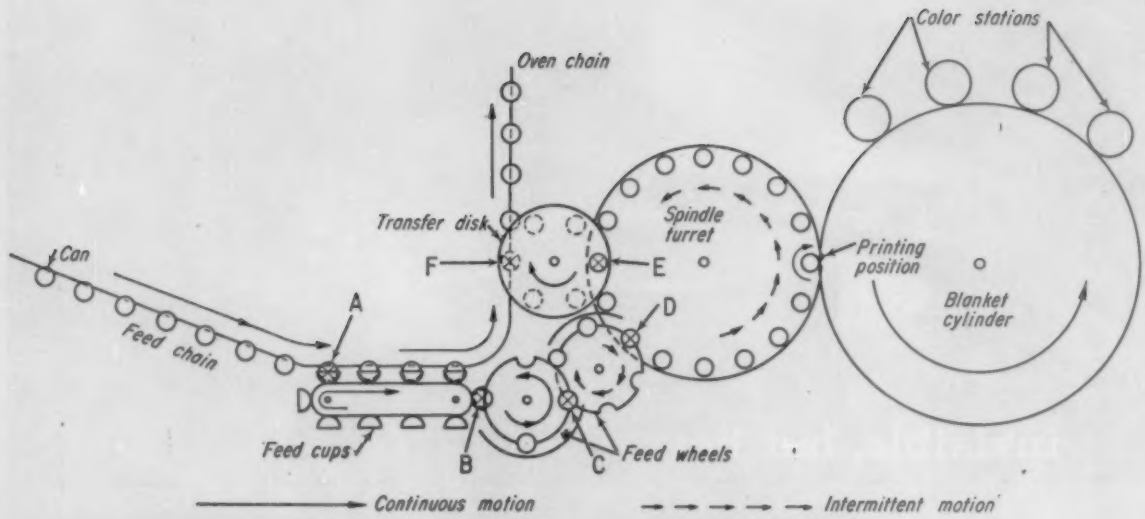
Four ink-feeders at top of machine can be removed, thus reducing downtime when changing brand patterns. Complex handling mechanism speeds up to 200 cans per minute through printer.

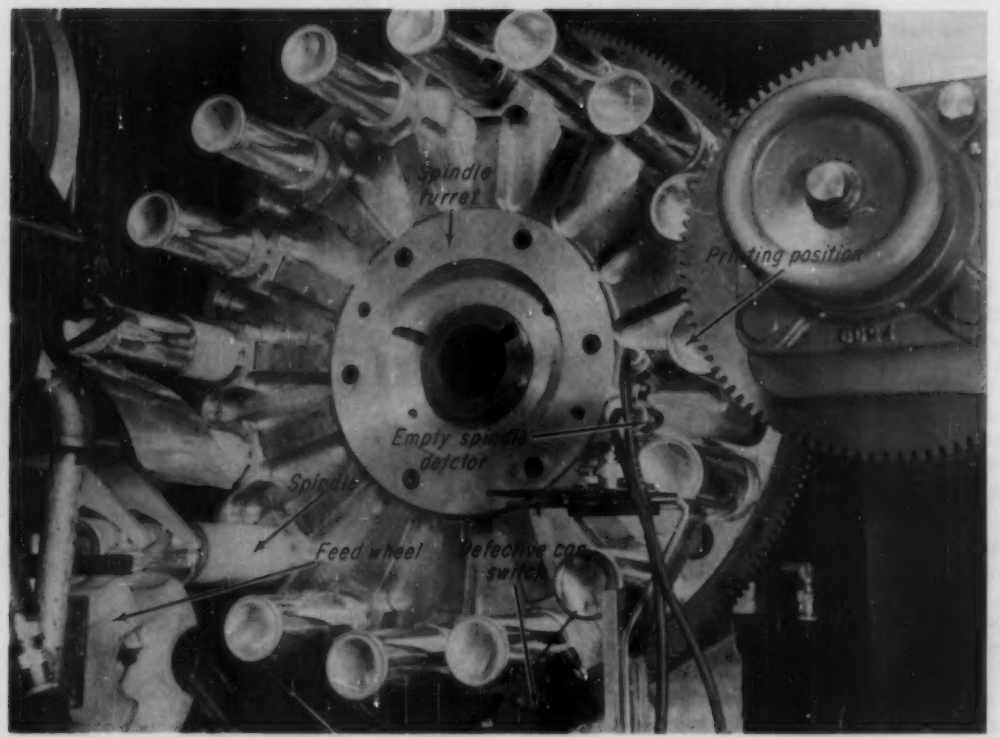


PRINTING OPERATION involves two problems: printing and can-handling. Four-color press is built around a blanket cylinder, which transfers the colored inks from the printing plates to the cans. As the cylinder passes each color station, the four offset presses each deposit one color on the rubber blanket. The four colors are deposited in precise registration, and when the blanket contacts the can, all four colors are transferred in one rotation.

Where succeeding jobs involve the same size cans, spare ink-feeders called "color stations" may be made ready as the press continues to operate. To switch jobs, complete color stations are removed by overhead winch and new ready-to-go stations substituted. To facilitate off-press registration alignment of printing plates, a preregister jig is used. This consists of two microscopes mounted to focus on opposite sides of the plate or impression roller. Reference marks on all four plates serve as guide for positioning each plate on the roller so that precise registration is achieved when the color stations are mounted on the press.

PS . . . Can-printer uses dry offset process to print aluminum, tin-plate or plastic cans in four colors. Complete system consists of coater, which applies base coat; four-color press to apply the desired print; plus drying ovens. A make-ready bench incorporates an optical preregister device that makes it possible to position printing plates accurately. First unit was produced for Kaiser Aluminum Corp by Rutherford Machinery Co, Div of Sun Chemical Corp, Rutherford, NJ.





CAN-TRANSFER line for four-color printer receives cans from the feed chain that carries coated and dried cans. At first transfer (A) air jet blows cans from feed chain to feed cups. Cans are passed (B) from feed cups to the feed wheels. Continuous-motion feed wheel transfers cans (C) to intermittent feed, which matches motion of the spindle turret. Rotating cam at (D) starts can on spindle where suction pulls can snugly into position. After printing, can is blown from spindle (E) and held on the transfer disk by vacuum cups, which contact the base. Final step (F) is to blow the can from the transfer disk back onto the pins of the oven chain.

Photo-cell detector moves the turret spindles out of contact with the printing and coating rollers if a can is missing from the spindle about to reach the printing stage. If a series of empty spindles reach the printing stage, the turret moves away and stays away until reset. If a can projects beyond the end of the spindle because it is deformed, it touches a switch lever that causes a compressed air jet to eject the can.

invisible, but hot...

ELECTRON BEAM WELDS IN VACUUM

T H CRANE, *chief metallurgist*
High Vacuum Equipment Corp
Hingham, Mass

Electron-beam welding is a new and sophisticated way to join most of the difficult-to-weld metals—highly reactive ones like zirconium and titanium, refractory metals like tungsten and molybdenum, and high-thermal-conductivity metals like copper and silver.

An outgrowth of the X-ray tube and the electron microscope, this vacuum process directs a precisely focused stream of high-velocity electrons at the weld zone—fusing the parent metal as the electrons give up their kinetic energy on impact. The advantages are largely metallurgical:

Weld-fusion zone is very pure. Electron-beam heating takes place in a vacuum, with atmospheric pressure below 2×10^{-4} mm Hg. This means that the impurity level is less than 1 part per million, compared with 15 to 20 ppm for the best commercial shielding gases. A second purity bonus: nonmetallic inclusions are automatically removed. Oxides, nitrides, and carbides undestroyed by heating in vacuum are ionized positively by electron bombardment, lifted out of the melt by the vacuum and attracted to the grid of the electron gun. Resulting welds show the improvement in properties and porosity expected from vacuum melting.

Heating is confined to a narrow zone and can be very rapid. Precise control over the electron stream gives production butt-welds with depth-to-width ratios of 2:1 to 5:1, roughly the reverse of inert-gas metal-arc welding. (Ratios up to 20:1 are possible.) Thus heat distortion is minimized, and delicate parts can be joined. Sharply focusing the electron stream gives high electron density, hence a high rate of heating. This, combined with the narrow heating zone, minimizes heat-conduction losses, so that high-conductivity metals are easily welded.

Heating is continuously variable. The weld zone can be barely warmed—or blasted with a power intensity that will boil tungsten. Transition between the two can be made smoothly by varying voltage; the start and stop puddles required in arc welding are not needed. There is no spatter. Pre- and post-heating can be done in the same equipment.

THREE INHERENT LIMITATIONS

Electron-beam welding has three major limitations, owing to its unique features:

Vacuum chamber limits size of the part and maneuverability. Maximum chamber size to date is about 42 in. ID x 10 ft long, some of which is used for fixtures and controls that manipulate either the part or the gun, depending on the welding machine. Because of the vacuum, all such motion must be controlled externally, whereas in an inert-gas glove box the operator has freedom of hand motion.

Narrow heating zone requires close fit-up. Electron-beam diameter varies from 0.010 in. for very high-voltage

Electron-beam Welding—*how it works*

■ The typical electron-beam welder functions like an X-ray tube in that high-velocity electrons emitted from a cathode current source bombard the work to be welded. A major difference is that work bombardment must occur in a vacuum, since only at very low pressure (below 2×10^{-4} mm Hg) is it possible to obtain substantial heating from the impact of an electron stream. This vacuum, needed for electronic reasons, also confers obvious metallurgical advantages since it is the purest, most inert welding atmosphere available.

The emitter is housed within an electron-gun structure, which serves as a control grid. The hot cathode produces cloud of electrons which emerge through a small sharp-edged hole provided on the side of the gun nearest the work. As they leave this hole, a high negative grid potential constricts them into a small-diameter beam, following the rule that like charges repel each other. This beam is focused by electromagnetic or electrostatic methods (or a combination of the two) developed for cathode ray tubes and electron microscopes.

The electron stream is accelerated toward the work by a high-voltage potential, usually above 15 kv. Electron velocities can be as high as 75% of the speed of light. The individual electron, with a mass of 9.1×10^{-28} grams, strikes the work and gives up its kinetic energy as heat. The total amount of this impact heating, Q in cal/min., can be calculated from the product of the accelerating voltage E and beam current I as: $Q = 1.4 \times 10^{-3} EI$.

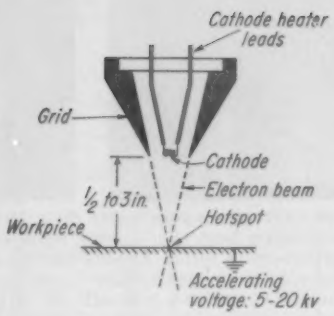
Two Types of Gun

There are two distinct methods for accelerating the electrons, resulting in two types of guns—each with different focusing means. The distinction is important, because both guns won't do exactly the same jobs.

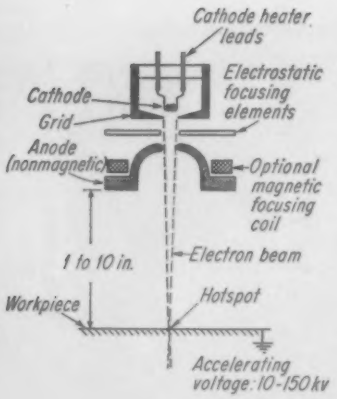
Work-accelerated gun is the simplest (see sketches). A moderately high voltage, 5 to 30 kv, is applied between the gun and the workpiece. The work thus becomes part of the focusing system—much like the screen in a simple movie projector. Focusing system consists essentially of a shielded tungsten filament behind an electrode with an aperture. Most welding is done at 5 to 20 kv with up to 5 kw power, and beam diameters range from $\frac{1}{16}$ in. to $\frac{1}{4}$ in. The work must be placed precisely at the electron-beam crossover point to get maximum heating—making electronic stability somewhat dependent on joint design.

Addition of magnetic focusing and higher voltages to this simple gun gives much greater concentration of heat, allowing deeper penetration and a narrower fusion zone. Such a combination is very similar in design and complexity to an electron microscope, and costs roughly five times as much as the simple work-accelerated gun. Using voltages up to 100 kv at about 1 kw, the high-voltage welders can also be used for machining intricate holes—using beams of less than 0.010 in. dia. These machines must be shielded against X-ray emission, and they require highly skilled operators.

Self-accelerated gun combines the best features of the low- and high-voltage work-accelerated guns. Both cathode and anode are contained within the gun—along with an electrostatic focusing lens. Electrons are accelerated within the gun, leaving through an aperture in the anode. Thus the workpiece is no longer part of the focusing system, and the space between gun and work is field-free. This means that nonsymmetrical parts with sudden protrusions cannot influence beam behavior, and that the gun can be mobile. Beam diameters range from $\frac{1}{8}$ in. to $\frac{3}{8}$ in., with 0.010 in. possible if a magnetic focusing coil is added. Voltage level is 10 to 30 kv at 5 to 10 kw. ■



Work-accelerated Gun



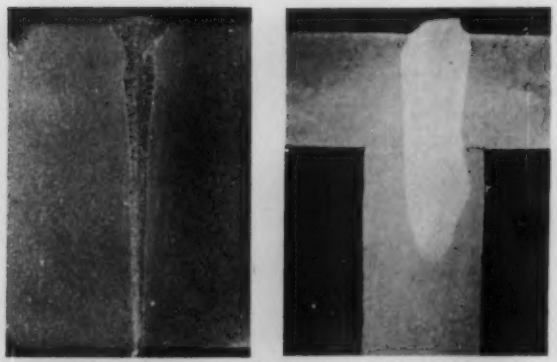
Self-accelerated Gun

machines, to $\frac{1}{8}$ in. for moderate-voltage welders. Since heating depends directly on the amount of weld area hit by the stream, variations in gap will give variable strength along the weld. Then too, filler metal cannot be added, so that when edges don't match—in sheared edges, for example—the beam will open the seam, rather than weld.

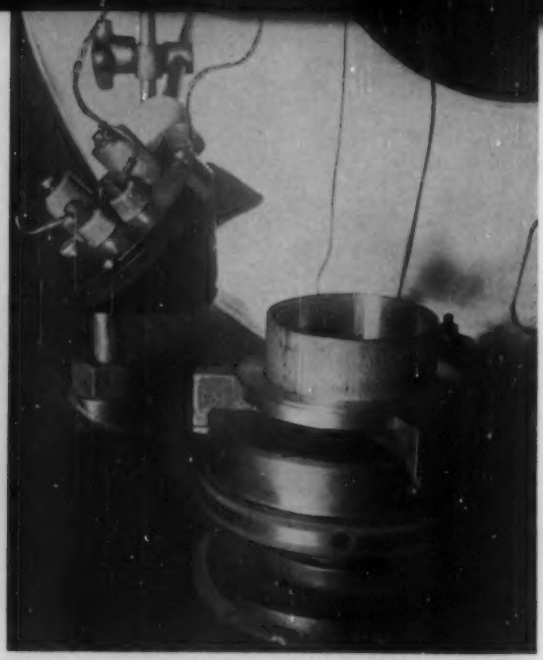
Specialized equipment is expensive. Although beam welders are made up of such standardized components as power source, vacuum chamber, control console and elec-

Metals Weldable with Electron Beam
(in order, from easy to difficult)

1. Tantalum, niobium
2. Titanium
3. Zirconium
4. Platinum-group metals (including rhenium)
5. Ferrous-base alloys
6. Copper
7. Molybdenum
8. Tungsten
9. Beryllium
10. Aluminum
11. Magnesium (best with pulsed beam)



Two unusual one-pass welds show how electron beam can concentrate heat in a narrow zone, giving unusually high depth-to-width ratios. At left: 0.400-in.-thick Type 302 stainless welded on high-voltage Hamilton-Zeiss electron-beam machine. Depth-to-width ratio is 20:1. Right: continuous "spike" weld made by NRC Equipment Corp welder on Type 347 stainless approximately 0.20 in. thick. Here, depth-to-width ratio is 4:1 since welder is low-voltage type; corners were not accessible for welding. Porosity in joints made by beam welding is extremely low, increasing slightly as depth of penetration increases.



Work-accelerated gun in position ready to make corner tube-to-flange weld. Workpiece is chuck-mounted and rotates past the fixed gun. Electron beam is shaped by conical grid, with the weld area positioned at the beam's crossover point for proper focusing.

Liquid-nitrogen container gets head-to-shell joint with wide-pass electron-beam weld. Large beam diameter is used to broaden fit-up tolerances and give weld better strength at low temperature. Cap and tube are 2-in.-OD stainless Type 304; require no precleaning.

tron gun, each welding job requires special handling devices, controls and the like. In aggregate, equipment costs usually exceed $14,000. This cost is easily borne when the joining job can be done in no other way; when a competitive process is available, costs and product quality must be weighed carefully.

MANY MATERIALS WELDED

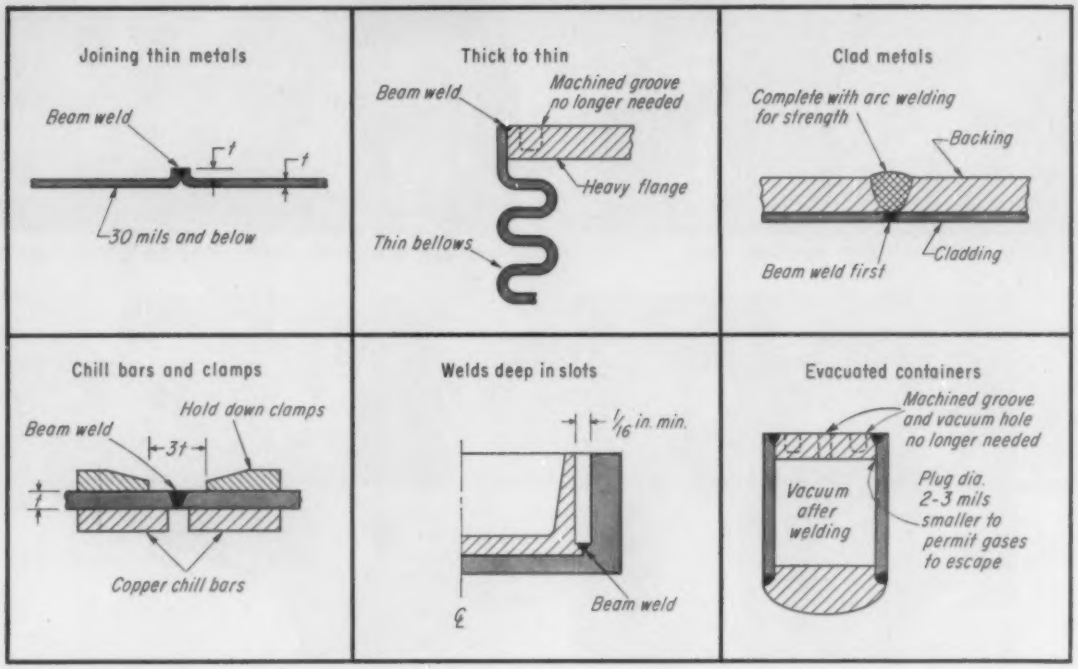
Weldable materials include all the metals and metalloids except manganese and chromium. Alloys of these two are readily weldable, but the pure metals have vapor pressures too high for vacuum welding: too much metal escapes by boiling to make sound joints. The table on page 71 lists metals that have been welded successfully so far. Of these, aluminum can give trouble if not precleaned adequately; with the same two-step treatment for spot-welding aluminum, good nonporous welds become routine shop practice.

Vapor pressure at melting point is main criterion in the ranking in the table, though gas content of some metals is also a factor. For the metals with higher vapor pressures —tungsten, magnesium and others—the key is high welding speeds. By welding at 50 or even 100 in. per min., enough metal can be retained at the mating surfaces to make the joint. High speeds minimize the danger of vapor bursts interrupting the electron beam—even in the simple work-accelerated gun (see "How It Works"). The more complex, self-accelerated gun is less sensitive to interruptions and, in extreme cases, can be pulsed for the very gassy metals.

Dissimilar metals can be joined because the heat can be highly concentrated. So far, there appear to be two major limiting factors, neither connected with melting point. First is the difference in thermal-expansion coefficients between the two metals being joined. Second is the formation of brittle alloy phases between them.

Invar to copper exemplifies a poor coefficient match—weldable as long as some flexibility is designed into the invar member. Titanium to any ferrous alloy is nearly impossible because of cracking in the brittle Ti-Fe interface that forms at the mating surface. Examples of suc-

Design Hints for Electron-beam Welding



cessful dissimilar-metal welding include: titanium to copper, mild steel to Alnico V, and aluminum to mild steel.

The two main effects of welding in a vacuum—removal of inclusions and prevention of oxide formation—combine to give electron-beam welds of unusual cleanliness. With the reactive metals like titanium, zirconium and vanadium, this results in higher-than-normal corrosion resistance and a drastic reduction in brittleness and notch sensitivity in the weld and heat-affected zone. For refractory metals like tungsten, tantalum, molybdenum and niobium, welding is now a feasible production technique and the increase in hardness usually associated with weldments of these materials is no longer so great. Welds of tungsten and molybdenum are still not as ductile as desired, however.

DESIGN CONSIDERATIONS

Despite the variety of equipment commercially available, as shown in these pages, electron-beam welding is just establishing itself as a production process. This means much has to be learned about the specifics of designing for the process. Here is what experience has shown to date:

Thicknesses that can be welded range from 0.001 in. min to about ¾ in. max. so far. If weld geometry is unimportant, thicknesses up to ¼ in. can be welded in the so-called low-voltage machines (10 to 30 kv). This will give a depth-to-width ratio of 2:1 or 1:1. For a narrower fusion zone, or for thicknesses over ¼ in., the high-voltage machines (50 to 100 kv) must be used. Foil can also be welded to gage-size stock without warping the thinner material.

Fit-up and welding-fixture tolerances are related to hot-spot size. Run-out on fit-up plus fixture should not exceed 10% of the beam's focal-spot diameter, or else the beam will try to machine rather than weld. Weldments with many joints can be designed with over-all tolerance of ±0.005 in., or approximately ±0.001 in. per weld. These figures are conservative: finish-machined stainless flanges have been welded to stainless tubing with a tolerance before and after welding of ±0.0002 in.

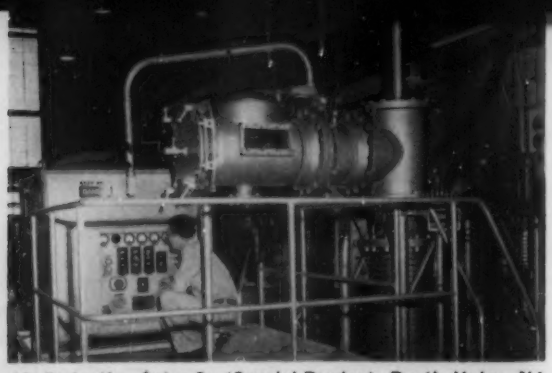
Strength of the joint is still controlled by the as-cast structure of the weld, and 90 to 95% of base-metal tensile strength is still a good design value. There is a greater spread between yield and ultimate strength since vacuum-melted materials are more ductile.

Heat-affected zone should be kept narrow as possible when welding refractory metals or alloys in the heat-treated condition. Depth-to-width ratios depend on alloy system and voltage. For the low-voltage welders, 4:1 in stainless, 2:1 in zirconium and aluminum, and 1:1 in tungsten are common. These may be improved through use of chill bars, by increasing linear welding speed, or by going to a high-voltage beam welder.

Geometry of the weld should be a regular figure, traceable by circular and/or linear motions, rather than a complex curve. The gun or the work can be manipulated, but the vacuum chamber forces these movements to be performed mechanically. The electron gun must also be able to see all parts of the seam, since the electrons travel in straight lines from source to object. The self-accelerated gun is a distinct advantage here because its focus is not interlocked with workpiece position, allowing the gun to be mobile.

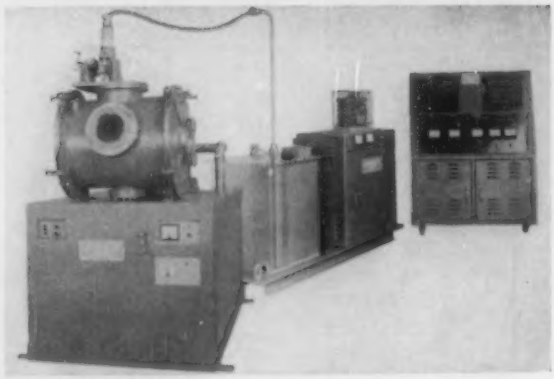
Clad metals are easily welded, but plated materials are more difficult: conducted heat from the weld can be enough to evaporate the plating from the heat-affected zone. In these cases, high welding speed will help—along with chill bars to conduct away excess heat. Feasibility of

High Vacuum Equipment Corp, Hingham, Mass

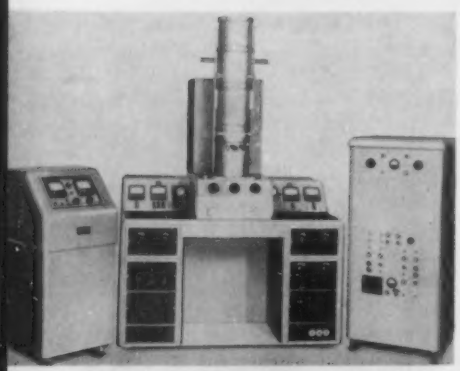


Air Reduction Sales Co (Special Products Dept), Union, NJ

NRC Equipment Corp, Newton Highlands, Mass



Sciaky Bros Inc, Chicago



Hamilton Electrona Inc, New York

Five electron-beam welders available for work

These five welding machines are commercially available in this country. Differing in design and appearance, all contain the same basic components: a vacuum chamber and pumping equipment capable of evacuation to 2 x 10^{-4} mm Hg or below, an electron-emission and focusing system within the chamber, a fixture to support the workpiece and move it under the electron beam, and a high-voltage power supply with appropriate adjustable controls. Basic units only are shown here. First five machines are the so-called 'low-voltage' type (15 to 30 kv) and sell for $14,000 to $30,000. The sixth machine, a 'high-voltage' type (50-100 kv) developed by Zeiss, sells in the $75,000 range, or leases for about $25,000 per year. Optional equipment, such as special motion fixtures, special beam-focusing and deflecting devices, TV viewing systems, and pulse generators are available on many units at extra cost. In some cases, the electron guns can be adapted to existing (or specially-constructed) vacuum chambers. Note: Sciaky Bros welder was developed under license with the French Atomic Energy Commission.

welding a plated metal should be established by experiment, since weld geometry and the metals used both play an important part in the cooling process.

Dissimilar-metal joints require careful stress analysis to see that adequate flexibility is provided for differential thermal change. Phase diagrams of both metals should be studied to determine whether brittle intermetallics or brittle alloy phases form under rapid cooling.

EDITOR'S NOTE: Other recent articles on the special problems of joining metals include the following:

How to Choose the Right Solder Flux, June 13 '60, p 43—An up-to-date flux-selection guide, based on chemical origin, covering all significant types.

High Frequency—What It Means to Welding Design, Jan 4 '60, p 42—Operate a welder at 450 kc and above, and you get stronger welds in a wider variety of metals.

How to Choose the Right Electrical Connection, Dec 7 '59, p 71—Here for the first time are direct comparisons among all electrical connection methods—permanent and separable. Articles give data from all sources.

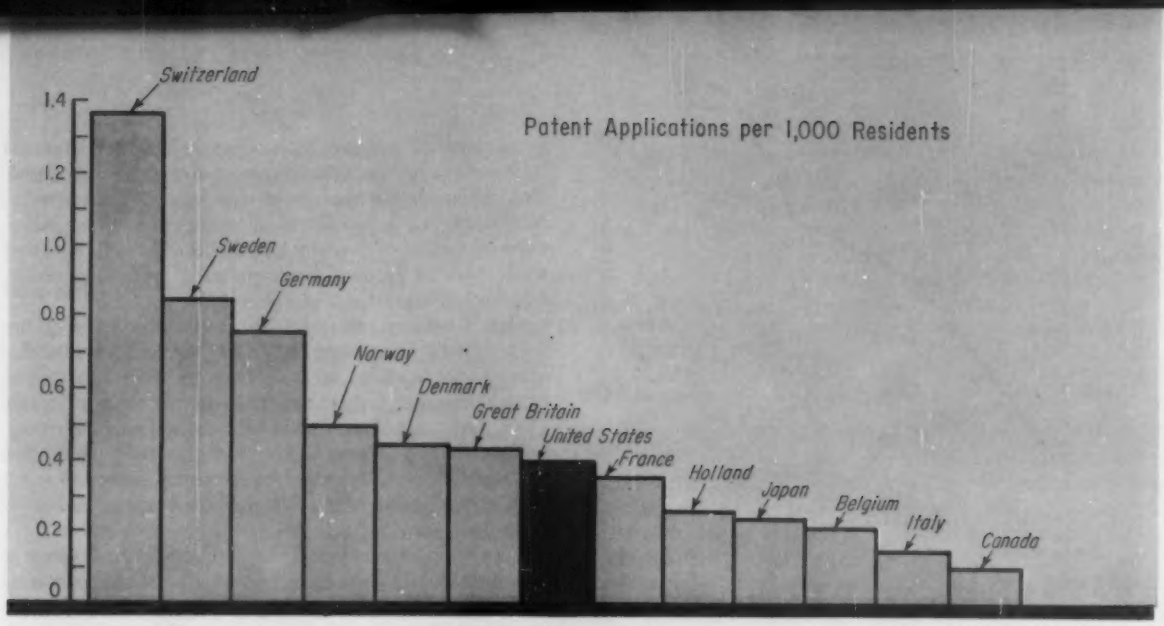
What the Tests Show About Soldered Aluminum Joints, Dec 7 '59, p 84—There are dozens of aluminum solders to choose from and each has its own characteristics. Here's how they're used and how they age.

Assembly Methods . . . an Engineering Roundup, June 8 '59, p 91—A solid package of illustrated how-to's that will solve some tough assembly problems, or spark answers to others.

One Temperature for Successive Brazes, Dec 8 '58, p 84—Article shows how tighter production control with special brazes allows multiple brazing without reducing operating temperature of final assembly.

Magnetic-force Welding for Vinyl-clad Steel, Sep 15 '58, p 82—A method developed for electrical contact metals shows great promise for a new, but difficult-to-join engineering material.

Stresses in Adhesive Joints, July 7 '58, p 64—Article analyzes six basic joints and shows how to calculate stress concentrations in each.



WE ARE WELL DOWN THE LIST of industrial countries in the patent statistics for 1950-1954. The figures come from the central office of the International Convention for the Protection of Industrial Property at Bern and from the countries themselves. They account for 89% of all patent applications of the Convention countries.

the lagging pace of US INVENTION

We're not nearly such great technical inventors as we seem to think. The author here presents some figures that put the US well down the list of the most creative countries.

FRANK A HOWARD
President
Sloan-Kettering Institute for Cancer Research

The first thing we must face up to, I believe, is that our country, which we have long regarded as the leader in technical progress as shown by our efficient industries and high standard of living, is far from being a leader in per capita output of inventions. The Swiss produce, per capita, more than three times the number of patent applications that we do; the Swedes more than twice as many; and both the Germans and the English outrank us. In fact, our per capita output of creative technical ideas seems to be nearer the bottom than the top of the list of mature industrial countries.

My authority for these surprising figures, so at variance with our traditional view of ourselves as a nation of prolific inventors, is a study of the world output of patent applications over the years 1950-54, made by the French Association of Patent and Trademark Agents (Compagnie des Ingenieurs-Conseils), and published by the French Ministry of Commerce and Industry in 1957.

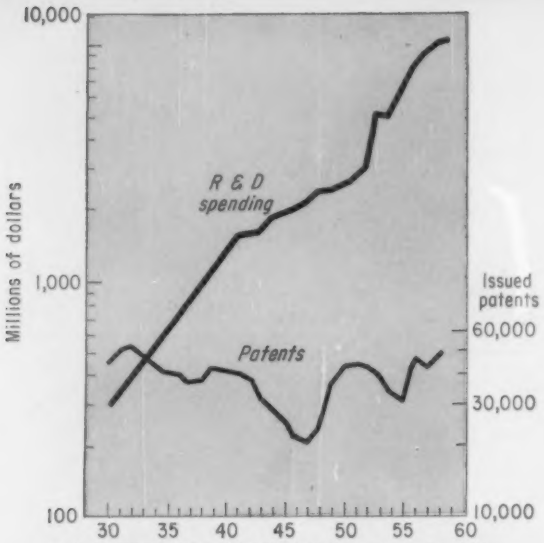
The figures compared above are not the total patent applications filed in each of the countries in question, but rather the applications filed in each country by its own people. The Commissioner of Patents has recently collected similar figures for 1958 which generally confirm the trends shown by the French figures of 1950-1954.

Next take a look at US patents between 1930 and 1959. In 1930 the figure was 45,000 patents. The number issued each year declined into and through the war years, dropping to a low of just over 20,000 in 1947. The postwar climb brought us, in 1958, to 48,400, 7% over the 1930 figures. But during this same period of 30 years our population grew about 45%, so that the per capita output of US patents over this period declined by about 38%.

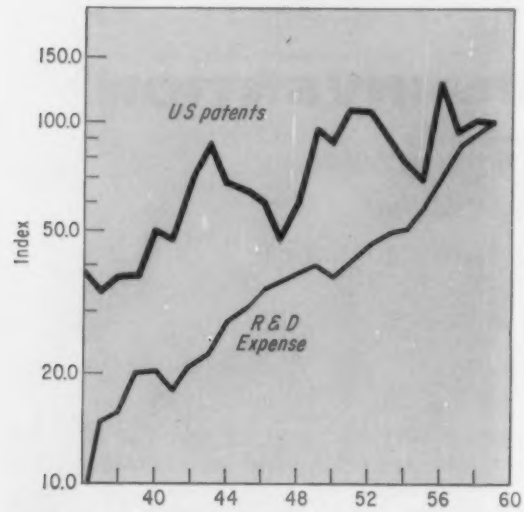
Let us now compare this rather sharp downward trend with the trends in some foreign countries. In Canada and England the trend is also down, but only by 5% and 6% respectively. West Germany is now producing 20% more patents per capita than prewar Germany produced in 1930, and in France the trend is also upward. I am afraid that we must, therefore, accept the fact that our per capita output of inventions is not only low in the list of industrial countries but that it has declined much more, over the last 30 years, than that of other leading industrial nations.

The Reasons

The fact that our total output of patents has not increased over a long period of increasing population and



R & D EFFORT IN THE US has risen tenfold—but issued patents remain at roughly the same level. A constant 60% of these patents has gone to corporations throughout the 20-year period, despite the sharp climb in R & D investment.



RECORD OF A SINGLE COMPANY for straight industrial research looks more encouraging. R & D matched the national ten fold increase, but the number of patents tripled.

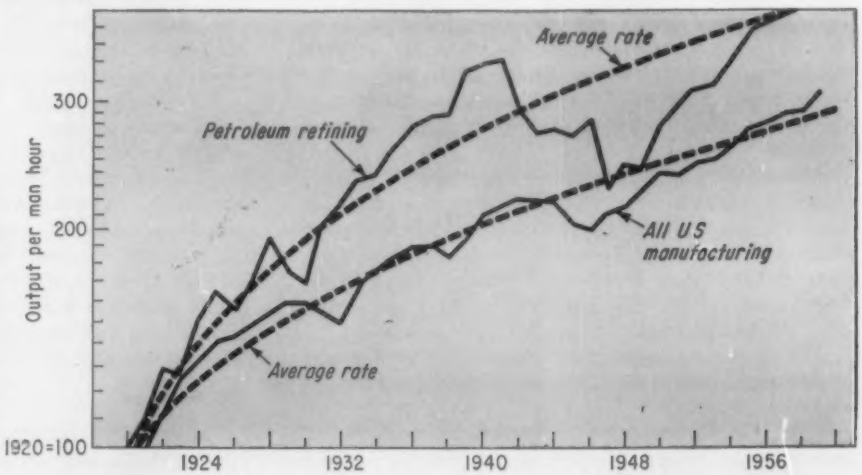
great technical and economic advance, has been observed by many people, and many explanations have been offered. One explanation is that there is a growing concentration of research and experimental effort by corporations rather than by free-lance inventors; and that this well-organized work tends to produce fewer patented inventions which, however, have greater economic value.

Data on this point (published in the first issue of the Foundation's Digest—see Ed Note) seems to refute the idea. There has been no real change in the percentage of patents issued to corporations between the years 1936 and 1955. Over this 20-year period the figure remained practically constant at about 60%. Over this same period the organized R & D effort of the country increased more than tenfold—from about 700 million to about 8 billion dollars per year.

This enormous increase in organized R & D, over a period in which our total output of patents remained about constant and our per capita output declined sharply, creates an impression that the output of inventions is not at all proportional to the amount of R & D. The major part of our national investment in R & D is made up of costly engineering development projects, such as atomic energy and military work that does not produce as many inventions as normal private research does. It also includes research in areas such as public health in which invention plays a very small part.

I have, therefore, made an effort to see what happens to the output of inventions in a typical industrial research and development organization of large size, operating in a mature industry, and over a long period. Here (at left), taking the year 1959 as the base, the increase in research and development expense over 1936 was almost exactly tenfold, about the same as the national figure. But the corresponding output of patents by this industrial research organization did not stand still, it increased about threefold.

As in the case of the national figure, the rapid increase in R & D spending for this organization was in part attributable to inflation and in part to the high cost of some large-scale development work. Nevertheless, it is difficult



TECHNICAL PROGRESS may be measured statistically, though incompletely, as productive output per man-hour. These increases reflect the improvements in our way of life, even though the number of patents issued remained constant. The question remaining—has our patent system fallen behind society's progress?

to reconcile the threefold increase in output of US patents in a single large well-organized R & D effort with the tendency of the national output of patents to remain constant over the same period, despite a similar tenfold increase in the national rate of expenditure for R & D.

Man-years per Patent

The next figures to which I should like to refer give some indication of the amount of human effort which is involved directly and indirectly in the production of a patentable invention in present-day well-organized industrial research operations. Considered individually, inventions are unpredictable by their very nature, but long experience proves that one can safely rely upon a regular flow of inventions in the general area of an organized industrial research effort.

To measure the average size of the human effort underlying each invention in such a flow of inventions, I asked several friends to supply figures from their own research organizations and, for simplicity, chose the year 1955. While the patent applications filed in 1955 are based on earlier work as well as on current work, the offsetting factor is that the same personnel is laying the foundation for applications in later years. As might be expected, the range of figures depends upon the nature and maturity of the industry and the varying ratio of the more creative employes to the supporting employes engaged in this industrial R & D.

Taking the narrowest classification of creative employes, that is, technical or professional graduates engaged in scientific studies and in laboratory or small-scale experimental work directed toward technical inventions, the normal experience for research laboratories in the oil, chemical and electrical fields seems to be about 2½ to 4 man-years of effort for each patentable invention.

In the engineering field the man-years of effort underlying a patentable invention seems greater. In some industrial development groups where the professional personnel consists predominantly of process engineers, a representative figure seems to be about 10 man-years for each patentable invention. And the figure seems to rise to about 15 man-years in R & D in larger mass-production mechanical industries, on which my data is, however, quite meager.

The above figures are based upon the personnel classified as technical or professional which commonly, but not always, is restricted to scientific or engineering graduates (see *PE—June 20, p 59*). Each professional or technical employe must have the support of skilled and unskilled help of all categories, and this ratio varies widely, but a figure of 3 to 1 is fairly representative for research laboratory groups, and this figure can become indefinitely higher for large projects reported as "development."

One might, therefore, say that in the research laboratories of industry in the US at the present time each invention probably represents a minimum of about 7½ man-years of human effort. For the engineering and development phases of technical progress the work required is indefinitely higher. If we refer again to our previous figures and take the over-all national figures on expenditures for R & D and the total US patents now being issued, a calculation involving a number of assumptions indicates that the national average of effort underlying each patent issued to a corporation is probably now about 30 man-years.

This seems roughly consistent with the industrial research figures supplied by my friends in view of the lower yield of inventions in government research work and mixed government-industry research work which is included in the national figures. I have been able to make spot-checks on a few organized research groups in England, France and Germany and find that there seems to be no gross difference, although my figures are not adequate to use for industry or national averages.

A Measure of Technical Progress

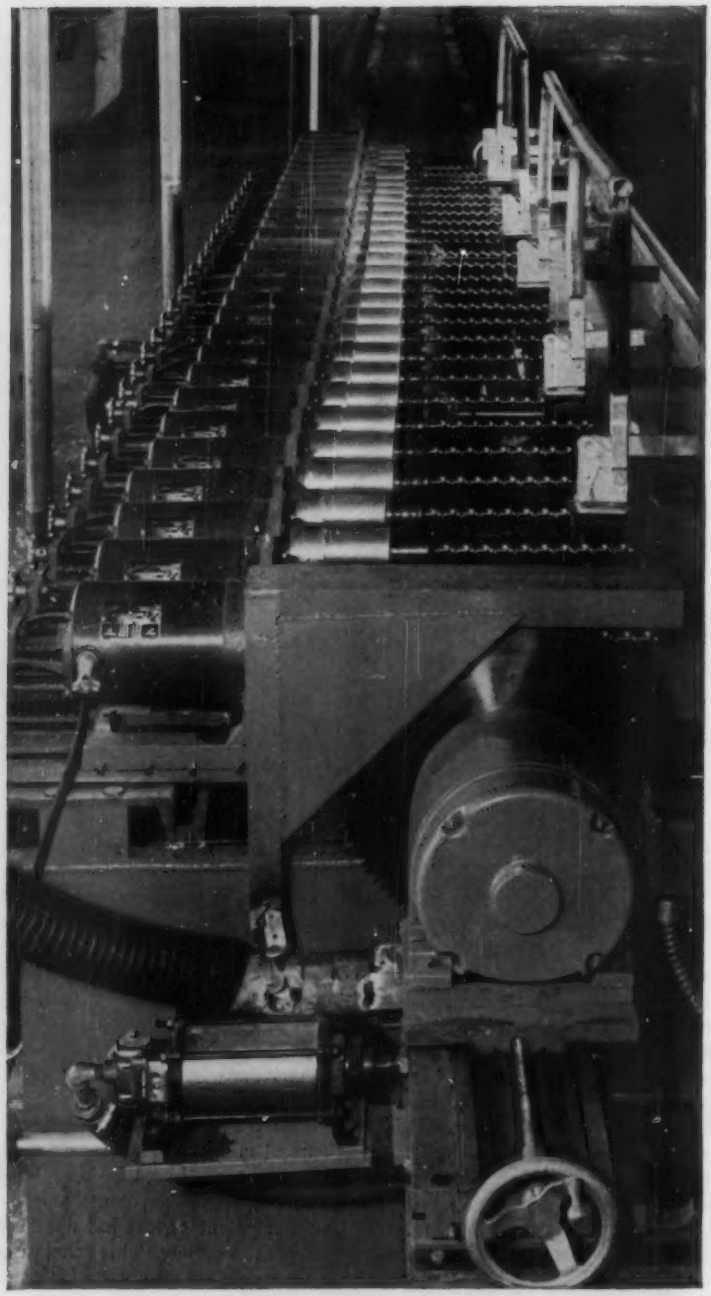
The last figures to which I should like to call your attention are an effort to find some way of measuring the rate of technical progress in this country. Such progress results in entirely new products and improvement of old products, as well as in new methods of production. As an example of technical progress in quality of product, we know that improvement in gasoline has kept pace with related improvements in automobile engines so that two gallons of gasoline now do the work which formerly required three gallons, and that an automobile engine of the same type, which formerly developed 30-60 hp, may now develop as much as 250 hp.

But it is impossible to find data of any kind to measure qualitative technical progress of industry as a whole. The only statistical common denominator for technical progress throughout industry seems to be the increase in output per man-hour. Using figures of governmental agencies for output per man-hour in all manufacturing establishments over the 40-year period 1920-1959, it appears to have increased at an average compounded rate of 2.9%/yr (bottom, left). I was interested to compare this figure with that of a single industry with which I am familiar, the petroleum-refining industry. Here the increase in output per man-hour over the same 40 year period was at an average annual compounded rate of 3.8%.

I have tried to correlate these curves of technical progress as measured by increase in output per man-hour with the number of patents issued each year. We have seen that the number each year declined sharply between 1930 and 1947 and has just now recovered, while over this same period technical progress has been very great. From this it would appear that there is no quantitative relation between technical progress and current output of patentable inventions; but this conclusion is not confirmed by records of straight industrial research and resulting patents.

Perhaps it is true that our patent system has not kept pace with our changing American society. This conclusion has been expressed in many quarters, but usually for quite different reasons, and much of the resultant effort has been spent in the search for abuses of the system, or in warding off the radical surgery prescribed for these alleged ailments. Perhaps it would now be more in the national interest to concentrate, for a time at least, on trying to strengthen the incentive effect of the patent system.

EDITOR'S NOTE—This article was taken from an address by the author when he received the 1959 Charles F. Kettering Award for meritorious work in patent, trademark, and copyright research and education. The speech was given at the fourth Annual Public Conference of George Washington University's Patent, Trademark, and Copyright Foundation, on June 16, 1960, in Washington, DC.



These Wagner Motors Provide...

A WHOLE BANK OF POWER FOR HOLE BORING

Those are Wagner polyphase motors lined up behind the bits. Thirty of them, each rated at one horsepower. They provide the muscle needed to drill thirty holes through six 2 x 4's, simultaneously and in six seconds flat. The saw on the end of the rig—powered by a five horsepower Wagner "Doubly Protected" polyphase motor—cuts the boards to size at the same time.

This wood boring machine, manufactured by the Indiana Foundry Machine and Supply Company, is installed in the new Kopper's Company, Inc. Plastics Division plant in Detroit, Michigan.

It's not too often that you see thirty motors lined up like this, providing power for one machine. But, whether the number of motors in a particular application adds up to 3, 30, or 300 . . . if they're Wagner Motors, you know they're really doing a job. That's usual, for Wagner Motors have been getting the job done for more than 65 years. And, a program of constant research and development in electric motor design makes sure that Wagner Motors will continue to lead *where it counts* . . . in performance!

Mind a suggestion? Call your nearby Wagner Sales Engineer for an analysis of your next motor application, be it for plant or product. Whatever your requirements, Wagner can supply a standard motor, or build a special motor to fit your needs. There are Wagner branches in 32 principal cities across the country, at your service.

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SERVING 2 GREAT GROWTH INDUSTRIES—*ELECTRICAL • AUTOMOTIVE*

what you should know about an important model-shop material—

POLYAMIDE-CURED EPOXY RESIN

PETER C NOY, *technical representatives, Nicromatic Ltd, Toronto, Ont*

Cured epoxy resin can be the design engineer's willing workhorse and a favorite in the model shop. But unless the curing is done with a polyamide you'll probably run into trouble—it will be either too hard and brittle, it may shrink too much, or it may not even cure properly, and you won't know why or what to do about it.

Advantages of polyamide resins over the many other types of curing agents are:

1. Precise calculation of required mixture quantities is unnecessary—by simply varying the proportions of polyamide to epoxy you can have either a hard or a flexible material. Cure time at room temperature is about 12 hours.
2. No skin irritation or toxic hazards exist with polyamide resin; also, it does not have an unpleasant odor.
3. The polyamide also acts as a "flexibilizer" that modifies the basic epoxy resin—a curing agent without this ability cannot change mechanical characteristics of the resin being cured.
4. Polyamide-epoxy compositions resist impact so well that they can replace steel as material for drop-hammer dies.
5. Exotherm and shrinkage are reduced—you can pour larger castings than with the unmodified epoxy.
6. Adhesive properties are improved in terms of shear strengths, peel strengths, low-temperature performance, and adhesion to flexible plastics.

PUTTING POLYAMIDE TO WORK

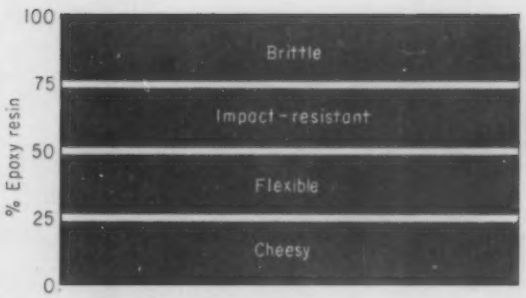
There are few difficulties in the way of complete success with your first attempt at working with epoxy-polyamide compositions. It's just a matter of mixing and pouring—but watch out for air bubbles, and be sure to get a thorough mix. Here's what to do to avoid trouble.

Mixing

To ensure homogeneity, mix the resins in a paper cup for about 5 mins. (A throwaway wooden tongue-depressor makes a good stirrer). If time is not skimped in the mixing you will never have a poor mix.

Air Bubbles

The mixture of 100 phr (parts polyamide per hundred parts resin) has medium viscosity and tends to develop air bubbles during mixing. With a pot life for 300 cc. at room temperature of about 1½ hours before cure starts, there is ample time for de-aeration. Best way is to place the mixture in a vacuum. Failing this, cover the surface with isopropyl alcohol to kill surface tension and tease the surface from time to time with low-velocity air. The bubbles will be soon eliminated.



PROPORTION OF POLYAMIDE to epoxy resin can be varied to produce flexible or brittle material. Within limits—the more polyamide, the greater the flexibility.

Pouring

For large castings—say, larger than a baseball—pour a cupful at a time and wait until each is cured before adding the next. The bond between the already cured resin and the newly poured mix, when set, will be virtually as strong as the homogeneous material itself. However, the fresh mix can be poured at the gel stage of the previous one—this slightly increases bond strength, slightly decreases total pouring time.

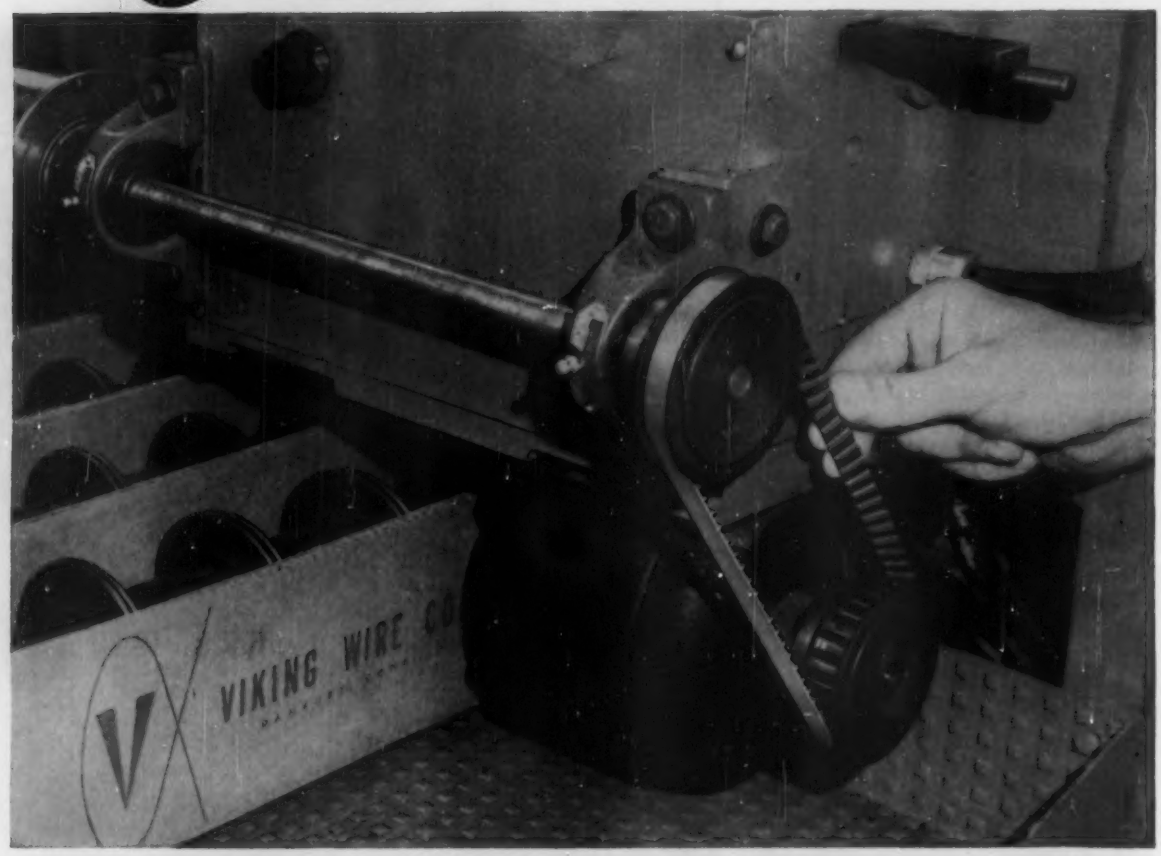
For castings under 5 lb, or thin sections, typical cure times vary from 3 hours at 150 F to 20 minutes at 300 F. Castings heavier than 5 lb do not require any external heat for cure.

Shrinkage

The only objection to pouring all of a bulky casting at one time is shrinkage. The larger the casting, the more the temperature rise owing to exotherm. The more heat involved, the greater the shrinkage will be. Best way for large castings is to pour about ½ gal. at a time, let it shrink, then pour another mix to fill out the walls of the casting. A suitable silicone release agent will prevent the epoxy from adhering to the mold.

continued on page 81

US RUBBER **PowerGrip** "TIMING"® BELT from the Power Unlimited complete belt line



NO "WRECKS" FOR THE VIKING WIRE CO., INC.

U. S. PowerGrip "Timing" Belts take the "wrecks" out of the Viking Wire Company's operation. This plant is one of the most modern in the business, producing fine-drawn enameled wire for electrical and electronic industrial customers. It specializes in producing long-length wires—giving it a definite sales advantage and profit.

The Viking Co. uses 26 U. S. PowerGrip "Timing" Belts exclusively on its wire-drawing machinery because the belts allow for a constant long-length draw through the dies with uniform speed and constant finished diameter on the wire. This ability to draw an uninterrupted length of wire sharply increases the company's efficiency in the enamel room. The production of long-length wire, once it is enameled, also steps up the production of its industrial customers.

This company also uses numerous U. S. PowerGrip "Timing" Belts in its enameling room because they provide constant speed drive, eliminating burns or over-insulation. A failure caused by a "wreck" always meant great loss in finished wire, with the oven out of production for several hours.

• • •

U. S. PowerGrip "Timing" Belts with speeds ranging to 16,000 r.p.m. and up to 1000 h.p. have made possible the design and production of hundreds of appliances and equipment, ranging from sensitive electronic devices, office machinery, household equipment and gigantic production machinery.

EXTRAS: • You can use a smaller, low-cost motor • Short and fixed centers, high ratio • Reduces assembly costs because fewer units are needed.

One way to get expert and instant power and transmission advice is from the U. S. Distributor.

US RUBBER Mechanical Goods Division

United States Rubber

WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS

Rockefeller Center, New York 20, N.Y. In Canada: Dominion Rubber Company, Ltd.

12 Basic Jobs for Epoxy Resin

Thermosetting with less than 1% shrinkage, cured epoxy resin is about seven times tougher—see Table I—than cured phenolic resin; it requires no pressure or external high-temperature for curing; it is a powerful adhesive and is extremely resistant to attack by strong caustics or acids. It performs like a champion for any of the following engineering requirements.

1. Models and prototypes.
2. Adhesive.
3. Metal solders (when mixed with powdered iron, aluminum, bronze, etc.)
4. Encapsulating electronic components.
5. Nests and fixtures.
6. Draw dies—mix with powdered iron and graphite for short runs and sheetmetal under 16 gage.
7. Patching cement floors—mix with sand, crushed stone, etc.
8. Patching castings.
9. Chuck jaws for irregular work.
10. Repairs to chemical equipment.
11. Fillets and repairs to corroded sheetmetal laminate with glass cloth over large, open areas).
12. For a tough paint, thin with isopropyl alcohol and fill with pigment.

RESINS AND FILLERS

Cost for the mixture is about $13 to $14 per gallon. Some sources for epoxy resins are:

Company	Tradename
Bakelite	ERL
Ciba	Araldite
Dow	DER
Jones-Dabney	EPI-REZ
Reichold	EPOTUF
Shell	EPON
For polyamide resin: General Mills (In Canada, Caledonia Chemicals)	VERSAMID
For fillers:	
Godfrey L Cabot	Cabosil
Monsanto	Santocel 54
Davison Chemical Corp	Hy-sil

These are fluffy fillers that greatly increase body of mixture without adding to weight. Other fillers are: Metal powders, glass fibers, cloth, plaster, sand, etc. In general, fillers will improve one or more characteristics of the cured resin—e.g. they can reduce shrinkage, lower the coefficient of thermal expansion, improve thermal conductivity, increase tensile strength—usually at the expense of the over-all properties.

TABLE I—Comparison of Epoxy-resin Strengths

Stress	Unmodified	Modified with polyamide (approx 100 phr*)	Test method, ASTM or Mil.
Tensile, psi	8000 to 12,000 psi, ultimate	4500 to 7000 ultimate	688-52TD (2-9)
Compression, psi	15,000 yield, 18,000 ultimate	7000 to 12,000	D695-54
Flexural, psi	18,000	7000 to 9,600	D790-49T
Elastic Modulus	400,000 to 600,000	200,000 to 300,000	By any of the above 3 methods
Impact resistance	0.2 ft-lb per in. width (Izod)	0.3 ft-lb per in. width (Izod)	ASTM D256-54T
	2 ft-lb (Falling ball test)	9 ft-lb (falling-ball test)	Mil-C-16923 Ships
Hardness, Rockwell M	100	Less than 5 to 100, depending on polyamide phr	ASTM D785-51

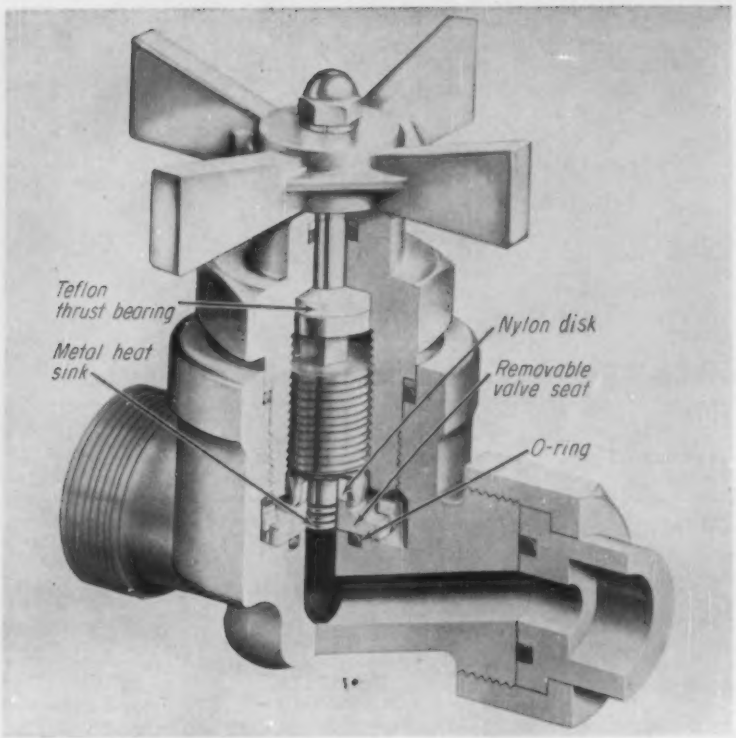
* Parts per hundred of resin

TABLE II—Properties of 3 Related Polyamides*

Property	Versamid 100	Versamid 115	Versamid 125
Amine value	83 to 93	210 to 230	290 to 320
Melting point, °C	43 to 53	Fluid	Fluid
Viscosity, centipoises:			
at 77 F	.....	.....	40,000 to 60,000
at 104 F	.....	80,000 to 120,000	.....
at 302 F	10,000 to 15,000	.....	.....

* Calculations have shown that stoichiometric quantities for typical epoxy-polyamide mixes are: For amine values in the 200 range, about 80 phr; for amine values in the 300 range, about 45 phr.

SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



Valve for 6000 psi . . .
liquid or gas service is said to provide bubbletight shutoff even when entrained foreign particles are caught on nylon disk, swaged into valve guide. Monel valve seat has O-ring seal. Designed to operate from —20 F to 275 F, valves are in all standard piping sizes from ¼ to 2 in., in globe, angle, needle, check and relief models. $5 to $150, depending on size and service. 2 to 4-wk delivery. **Combination Pump Valve Co, Dept 115, 851 Preston St, Philadelphia 4.**

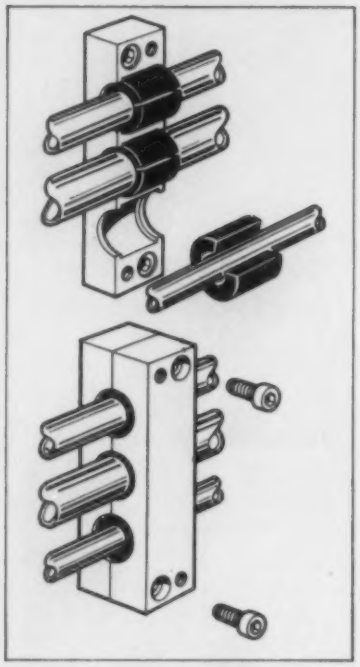
Circle 300 on Reader Service Card

Nylon with finer crystalline structure . . .
(spherulites are 2.1 microns max, compared with conventional 17 to 26) absorbs water much more uniformly, limiting warpage and distortion. Better molding characteristics and properties in finished parts made of the new nylon are reported. **Foster Grant Co, Leominster, Mass.**

Circle 301 on Reader Service Card

Bidirectional step motor . . .
provides starting, stepping and stopping for positioning or digital-to-analog conversion at frequencies up to 300 pulses per sec. Up to 100 steps per sec are possible with 80 in.-oz applied load; up to 200 steps per sec with 40 in.-oz applied load. Motor remains locked during dwell periods in pulse signal source with static break-away torque of 200 in.-oz. Will accept sine wave, square wave or triggered pulses as low as 6 v peak. Available with either rotary output shaft or nonrotating coaxial lead screw. **Farnham Div, Wiesner-Rapp Co Inc, 4050 Buffalo River, Buffalo, NY.**

Circle 302 on Reader Service Card



Tube-support brackets . . .
are stackable and adaptable to wide range of tubing sizes. Reported to eliminate hand-made clamps. Brackets comprise two clamp halves, each of which has a series of half-round holes. Clamp halves can be bolted to machine surfaces and to each other. Clamp is completed by slipping bushings with ID identical to tubes to be supported over tubes and then clamping bushing between bracket halves. All bushings have same OD. Clamp halves can be formed to support any number of tubes by cutting long sections with a hacksaw. Long model, about $4.25; shorter models are priced proportionately. From stock. **Thunderbird Industrial Equipment Co, 14601 Bredin Ct, Livonia, Mich.**

Circle 303 on Reader Service Card

Phase-shifting transducers . . .
are used at specific frequencies to produce continuous time delays or phase variations directly proportional to shaft rotation. Originally developed for measuring time intervals in radar ranging systems, phase-shifters have been applied successfully to measurement of angular motion and distance, studying frequency modulation, sine/cosine generation, industrial

measurement/control and in navigation systems. Transducers are complete phase-shifting systems, including capacitor, bridge network and balanced line components. Max operating speed is 5000 rpm. Capacity-coupled design eliminates brushes. **Nilsen Mfg Co, 23 N Church St, Addison, Ill.**

Circle 304 on Reader Service Card

Clutch has friction elements on OD . . .

permitting longer torque arm and greater friction area for given-size unit. Electromagnetic multiple disk-type clutch is flanged for attachment to engine flywheels or other driven mechanisms; also adaptable to through-shaft drives. Available in two-, four- and six-disk models, in 7-, 9-, 13- and 15-in.-dia sizes, with torque ratings up to 4000 ft-lb. Price, $1041; delivery, 6 wk. **Stearns Electric Corp, 120 N Broadway, Milwaukee 2.**

Circle 305 on Reader Service Card

Filled-Teflon 100-FEP resin . . .

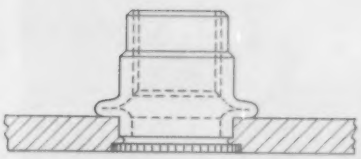
which is compounded with inorganic reinforcing materials, has been developed for injection molding. Said to be stiffer, to have smaller shrinkage factor (up to 50%) in molding operations and to have better wear resistance than unfilled Teflon 100. Now available filled with 10 or 20% fiberglass to injection molders. **Crane Packaging Co, Dept PE-1, 6400 Oakton St, Morton Grove, Ill.**

Circle 306 on Reader Service Card

Filter configurations . . .

for pumping units are designed to simplify intake piping. Body shapes permit installation on some existing pumping units without use of elbows, which means that pressure drop capacity of pump can be utilized to tolerate dirt in filter instead of being used up to lift fluid up to pump. Because amount of pressure drop in intake line can be limited by varying resistance of pressure-drop control spring, possibility of cavitation in pump is said to be eliminated. Automatic bypass opens before suction can become excessive. Shapes now available include bottom inlets, side inlets and side outlets. Regardless of body shape, however, all have sliding cartridge and external dirt indicator. **Rosaen Co, 1776 E Nine Mile Rd, Hazel Park, Mich.**

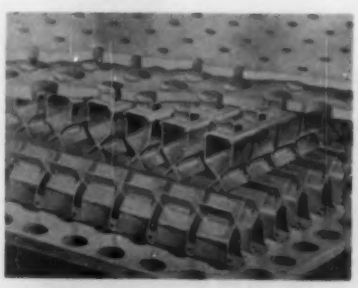
Circle 307 on Reader Service Card



Blind-mounting aircraft locknut

is one-piece, self-locking threaded fastener that is installed from one side in single drilled hole by pressure tool. Fastener is threaded internally and has small knurled collar or heat at one end. When nut is pulled under axial pressure for assembly, annular groove in interior swages out on reverse side to grip sheet. Austenitic stainless steel fastener is for use with 125,000-psi tension and shear bolting. Can be used in metal sheets 0.040 to 0.400 in. thick and of Rockwell C hardness up to 21. Made in standard sizes No. 10 through ¼ in. dia and in nine grip lengths 0.040 to 0.400 in., in 0.040-in. increments. **Standard Pressed Steel Co, Jenkintown, Penna.**

Circle 308 on Reader Service Card



Circuit-switching device . . .

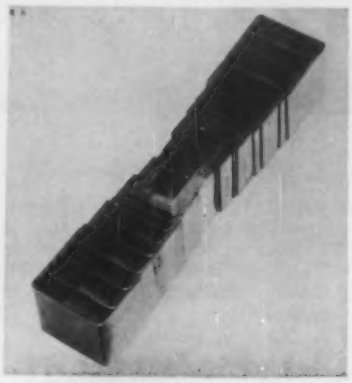
allows instantaneous setup or programing of circuitry logic between X and Y axes of terminations, without use of patchcords, and, at the same time, permits interposition of diodes of other miniature electronic components between any X and Y termination. Unit consists of two separate layers of formed, silverplated, beryllium–copper contacts mounted on plastic boards at right angles and separated by spacers. Two planes of contacts are connected in X and Y axis configuration to outside circuitry and can be connected at any point by insertion of shorting plug, eliminating need for dual pins and patching cord. Available in any size. Plug-ins are based on 0.250 x 0.250 in. modules. **Sealectro Corp, 139 Hoyt St, Mamaroneck, NY.**

Circle 309 on Reader Service Card

Oil-resistant plastic belting

is said to retain coefficient of friction even when large quantities of grease or oil are present. The all-synthetic flat belting is joined by heat sealing, without lacing or sewing. **R & J Dick Co Inc, Dept P60, Totowa, NJ.**

Circle 310 on Reader Service Card



Transformer 2 to 30% smaller

and lighter than types now in use has been made possible by forming core of laminations of steel strip from continuous roll. Resulting U-shape nests of laminations are fitted together, with strips at top of U's interleaved or meshed. Nested cores allow magnetic lines of force to flow continually with grain of steel, rather than across grain as occurs in "EI" laminations. This is said to reduce resistance of magnetic circuit, permitting new transformer to operate as efficiently as conventional unit that has larger, heavier core. Both "core"- and "shell"-type transformers can be made in any size ranging, at present, up to 18 x 18 x 36 in. **Dept FT, Sylvania Electric Products Inc, Ipswich, Mass.**

Circle 311 on Reader Service Card

Oil-resistant adhesive . . .

for general-purpose bonding of wood, felt, cork, insulation, fabrics, leather and some synthetic rubbers to themselves and to metals, produces bonds also said to be resistant to heat, cold, water and gasoline. Qualities are reported to improve with

continued on page 84

3 Ways to Slash Fastening Costs with

PALNUT®
LOCK NUTS and FASTENERS

1. Save on First Cost

PALNUT Lock Nuts and Fasteners are precision-produced in enormous volume at exceptionally low cost. They are priced lower than other locking methods, often less than plain nuts.

2. Save on Assembly Cost

PALNUT Lock Nuts and Fasteners apply easily and fast with ordinary tools. Assembly is greatly simplified and speeded-up by using PALNUT magnetized sockets and applicators which permit picking up, starting and tightening in one high-speed operation.

3. Save auxiliary parts and operations

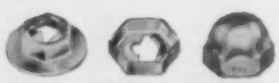
A single PALNUT Lock Nut or Fastener replaces two, three, even four fastening parts according to application. You can eliminate lockwashers, flat washers, sealer washers and cotter pins. You can save the extra cost of threading, drilling or grooving other fastening members. Assemblers handle a single PALNUT—reducing parts to buy, stock and assemble.

PALNUT LOCK NUTS for threaded members

Spring tempered steel lock nuts exert double locking action to keep parts tight.

PUSHNUT® FASTENERS for unthreaded studs and rod

Simply push on for fast assembly. Strong spring grip holds parts tight.



PALNUT SELF-THREADING NUTS

Make their own threads while tightening on unthreaded studs, rod and pins of any malleable material. Save cost of threading—apply fast—hold tight.

Write for latest catalog and free samples, stating type, size and application.

Also consult Sweet's Design File.

PALNUT®

THE PALNUT COMPANY
DIVISION OF UNITED-CARR FASTENER CORPORATION
65 Glen Road, Mountainside, N. J.
Canada: P. L. Robertson Mfg. Co., Ltd., Milton, Ont.

LOCK NUTS and FASTENERS

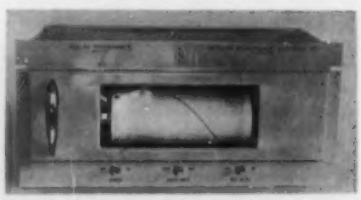
age and without loss of flexibility. Light-tan adhesive has brush-consistency viscosity. 1 gal will coat about 200 sq ft. Supplied in 1-qt, 1-gal, 5-gal and 55-gal containers. **Schwartz Chemical Co Inc, 50-01 2nd St, Long Island City 1, NY.**

Circle 312 on Reader Service Card

Inexpensive electronic counter

for automatic control of industrial processes, actuates equipment at any preset count from 2 to 100, at speeds faster than 1000 operations per min. In operation, batch count is set on direct-indicating switches. When count is reached, control relay closes momentarily (100 millisec) to operate external device. Counter instantaneously resets to zero and continues counting process. Priced at $148. Model designed for actuation in batches up to 10 sells for $110. **Standard Instrument Corp, 657 Broadway, New York 12.**

Circle 313 on Reader Service Card



Analog programer . . .

is arbitrary-function generator wherein any single-value function (Y) drawn on graph paper with conductive ink is converted to proportional voltage as function of time (X). Said to have accuracy of 0.5% and response time of less than 10 microsec to full scale. Consists of chart-supporting drum, resistive roller or potentiometer and two contact rollers. Synchronous motor, working through gear assembly, drives chart drum. **American Measurement & Control Inc, 240 Calvary St, Waltham 54, Mass.**

Circle 314 on Reader Service Card

Instrument-dehydrator units

connect directly into system line to protect sealed instruments, relays, sparking contacts and similar components from moisture, contamination, oil vapor, fuel vapor and corrosive or explosive gases. Fiberglass pads also control downstream particle size to less than 10 microns. Transparent housings permit desiccant material and moisture indicator to be visible at all times. Sizes are 1.125 to 2.81 in. dia, lengths from 2.25 to 9.72 in,

continued on page 85

weights from 0.07 to 1.25 lb. Throwaway and refillable types are offered. **Robbins Aviation Inc, 2350 E 38th St, Los Angeles.**

Circle 315 on Reader Service Card

High-capacity couplings . . .

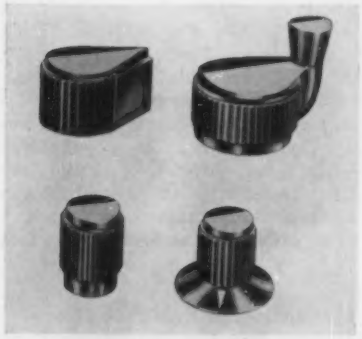
are shaft-rated to permit selection of flexible couplings by shaft diameters. All working parts are high-tensile steel, heat-treated for higher torque capacity and longer service life. Available in finished bore and taper-lock bushed types in stock sizes. 1155 different shaft diameter combinations can be accommodated. Also supplied for reboring to accommodate nonstandard shafts of $\frac{7}{16}$ to $6\frac{1}{4}$ in. dia. **Diamond Chain Co, 402 Kentucky Ave, Indianapolis 7.**

Circle 316 on Reader Service Card

Color-coded compression taps

have color bands that match corresponding colors on dies of installing tools to assure correct compression and permanent installation. Nine sizes will tap any two copper conductors from two No. 10s to two 1/0s and any combination of large main to smaller branch from No. 10 to 3/0. Tensile strength is said to exceed UL requirements. **Thomas & Betts Co, 36 Butler St, Elizabeth 1, NJ**

Circle 317 on Reader Service Card



Instrument-control knobs . . .

are designed to meet MS-91528 specifications for military applications. Knobs are molded of black Tenite No. 2 with

continued on page 86

Now the Bruning Man brings you the Whiteprinter that

GIVES YOU THE MOST

. . . THEN OFFERS MORE!

It's Bruning's Great New Versatile Model 600!

It gives you the most! And we'll just mention the 42" printing width, 5,000 watt lamp, automatic separation, and 75 fpm speed range. But consider such built-in extras as: a feeder-band system for extra speed and assured print protection, dual air filtering for cleaner and sharper prints, pressure-roller developer system for instant and positive development at all times, split-shade lamp control for simultaneous running of two different materials.

It offers you more! Now take your choice, to suit your needs and budget, of these options: a 7,500-5,000 watt lamp with selector switch, a 4-way tracing tray, an automatic level-keeping developer pump, a deluxe feedboard unit complete with vacuum ports, swing-out rods for roll stock, non-sag paper cutter, drawer, even an ash tray.

If you can't beat it, why not join the "600." It's easy with Bruning's Lease-Purchase plan. Call your nearby Bruning Man, or mail coupon for a prompt reply.

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Chace THERMOSTATIC BIMETAL

ACTUATES ANOTHER PRECISION PRODUCT

"Whether it's cold or whether it's hot" . . . the weather is still one of the big topics of every day. Helping you to keep track of the weather are those big billboard thermometers you pass along the way. And the readings on the big dials are accurate, too, thanks to T. W. O'Connell thermometer movements supplied to the electric sign industry. Simplicity is the keynote . . . all excess parts are eliminated. The big pointers are rotated by a direct drive which is motivated by Chace Bimetal Coils. Temperature range: minus 40° to plus 120°.

Many of the uses of Chace Bimetal are in areas far removed from the excitement and romance of missiles, rockets, satellites and so forth. Millions of temperature controls, switches, circuit breakers and, yes, billboard thermometers keep the American way of life functioning smoothly. In most cases we are hardly aware of the fact that they're at work, because they operate for years without care of any kind. Even the purposely simple O'Connell Movements must be built to withstand the rigors of exposure to all sorts of weather conditions. Chace's third of a century in manufacturing precision bimetal *only* is one of the main reasons why Chace is specified by large and small buyers everywhere, whether their products be complex or simple.

If your new product is approaching the design stage send for "Successful Applications of Chace Thermostatic Bimetal." It contains illustrations and design data on more than 30 different types. Chace bimetal is available in strips, coils and in completely fabricated elements of your design.

IT BENDS WITH THE HEAT

W. M. CHACE CO.
Thermostatic Bimetal
1607 BEARD AVE., DETROIT 9, MICH.

ribbed construction used in large-dia knobs. Standard shaft hole is ¼ in. Available for immediate delivery in six types, including rounds, skirted rounds, dial-skirted rounds, plain and skirted pointers and crank-types. Six different sizes are provided in mil-spec matte black finish and also in mirror finish. **Lerco Electronics Inc, 501 S Varney St, Burbank, Calif.**

Circle 318 on Reader Service Card

Three-phase induction motor

is said to develop 12.4 hp, 11,600 rpm in compact configuration that measures 5½ in. dia x 9$\frac{7}{16}$ in. long. Weighs 17.72 lb. Input is 200 v, 400 cps, three-phase, 10.1 kw, full load. In addition to being totally enclosed and explosionproof, motor also features thermal overload protection. Intended for airborne or ground-based axial vane blower applications. Said to meet requirements of MIL-M-7969A and environmental requirements of MIL-E-5272A, Procedure I. **Kearfott Div, General Precision Inc, 1150 McBride Ave, Little Falls, NJ.**

Circle 319 on Reader Service Card

Sealed time totalizer . . .

registers up to 9999.9 hr total operating or nonoperating time for any type of electrically controlled equipment. Entire unit weighs about 4 oz, is hermetically sealed and is said to meet, dimensionally, MS-28053 and NEMA standards. Required operating power is 115 v, 60 cps or 400 cps. Drum-type counter is driven by constant-speed motor from instant power is applied to motor circuit. Min life is reported to be 10,000 hr. **Cramer Controls Corp, Centerbrook, Conn.**

Circle 320 on Reader Service Card

Gasketing material . . .

is special Buna-N rubber compound that is reported to perform well in hot-oil applications up to 350 F. Said to have wider range of useful life between low and high temperatures than some poly-

continued on page 88

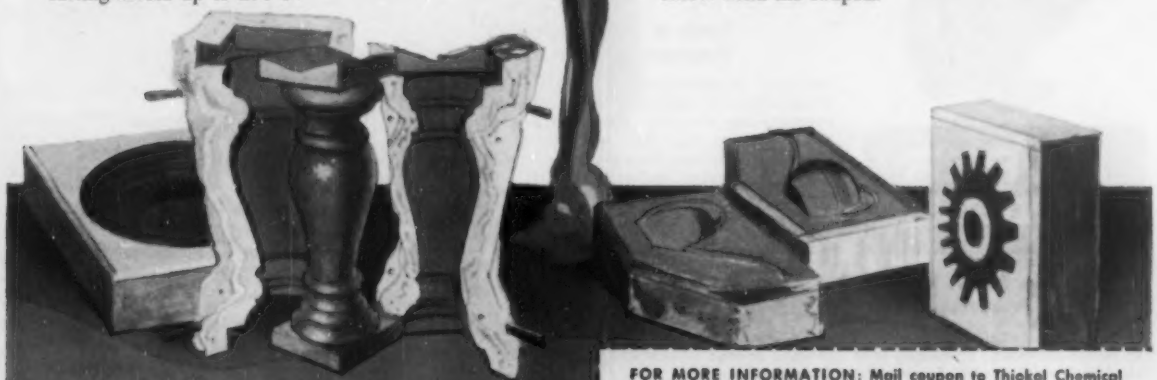
Wherever flexible tooling or molding techniques are adapted, compounds based on THIOKOL polysulfide polymer...

OUTCAST THEM ALL!

When polysulfide base materials supplement plaster of paris in originating, refining and producing molds, production efficiency and economy step up.

Properly formulated, these specialized materials pour easily and cure at room temperature. They are faithful to original models in detail and dimension. Accurate in reproduction. Unbreakable. Quickly reproducible. Unaffected by environmental conditions. Workable with practically all forms of cold casting media up to 250°F.

For over 10 years—automotive, aircraft and rubber manufacturers, pattern shops, potteries, foundries, art plaster shops and sculptors have successfully used THIOKOL polysulfide-base molding materials to develop prototype models and to produce perfectly cast parts in both small and large volume. Cold mold casting materials using THIOKOL polysulfide polymer are made commercially available by processors such as The Perma-Flex Mold Company. Want to know more? Send the coupon.



Thiokol®

CHEMICAL CORPORATION

780 NORTH CLINTON AVENUE • TRENTON 7, NEW JERSEY

In Canada: Naugatuck Chemicals Division, Dominion Rubber Co., Elmira, Ontario

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FOR MORE INFORMATION: Mail coupon to Thiokol Chemical Corp., Dept. FM-41, 780 N. Clinton Ave., Trenton 7, N. J.

Gentlemen: I'm interested in casting compounds based on THIOKOL polysulfide polymer. Please have details forwarded by manufacturers of these compounds.

Name_____

Firm_____

Street_____

City_____ Zone____ State_____

Thiokol supplies only polysulfide liquid polymers as raw materials for compounding by others as finished products.

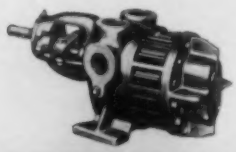
CIRCLE 87 ON READER SERVICE CARD 87

WHATEVER YOUR REQUIREMENTS FOR ROTARY PUMPS, THERE'S A ROPER TO DO THE JOB

Series T .3 to 55 GPM
Choice of 192 Models

Pump and motor units . . . pump serves as end bell of motor. Require minimum space . . . easily installed . . . no coupling required . . . mount in any position. Each unit approximately same size as NEMA motor of HP required for driving. Open drip proof or totally enclosed motors; single or three phase as required.

ROPER
ROTARY PUMPS



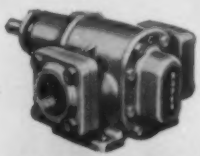
ROPER
ROTARY PUMPS

Series F 1 to 300 GPM
Pressures to 300 PSI

Feature helical steel pumping gears, hardened steel shafts, bronze flange-type bearings. 4-port design with 8 optional piping arrangements (4 for CW and 4 for CCW rotation) solves installation problems. With or without built-in relief valve in either mechanical seal or packed box construction.

Series K ¾ to 50 GPM
Pressures to 150 PSI

Extremely compact in all sizes. Helical pumping gears are hardened steel, with steel shafts and bronze bearings. Sizes 10 through 50 GPM have patented venturi suction and discharge principle for smooth flow and quiet operation. With or without built-in relief valve; packed box or mechanical seal.



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ROPER
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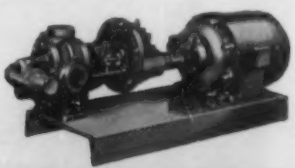
Series H 5 to 75 GPM
Pressures to 1000 PSI

Designed to operate at direct motor speeds. Used for all types of hydraulic mechanisms where high pressures are required. Hardened steel spur gears for maximum efficiency, and heavy duty roller bearings and bronze wear plates for long life service. Mechanical seal or packed box.

Series 3600 40 to 300 GPM
Pressures to 100 PSI

Handle thick or thin liquids at slow speeds. Operate in either direction. Hardened iron pumping gears, hardened steel shafts, heavy duty bronze sleeve bearings. Mechanical seal or packed box. Series includes tank truck pumps as well as single motor driven units with gear reduction.



ROPER
ROTARY PUMPS

Send for
"How to Solve Pumping Problems"

Roper Hydraulics, Inc. COMMERCE, GEORGIA
Manufacturers of Standard, Special and Custom Pumps for All Industries

acrylic materials now being used in similar applications. Suitable for such uses as automobile-transmission seals and oil seals. Armstrong Corp Co, Industrial Div, Lancaster, Penna.

Circle 321 on Reader Service Card

Rigid coupling . . .

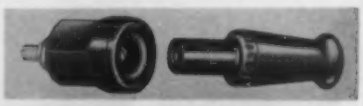
aligns and connects shafts by interchangeable tapered bushings that provide equivalent of shrink-fit when they have been tightened into the rigid sleeve. Precision-machined taper lines up two shafts automatically as proper torque is applied. Five sizes cover shaft-dia range of ½ to 5⅞ in. T B Wood's Sons Co, Chambersburg, Penna.

Circle 322 on Reader Service Card

Adjustable temperature controls . . .

are available in two models for volume applications where humidity, condensation and similar environments would cause problems. Both units have fraction-of-degree sensitivity. One model has adjustable range of 0 to 175 F; the other has range of 0 to 225 F. Fenwal Inc, Pleasant St, Ashland, Mass.

Circle 323 on Reader Service Card



Single-conductor plugs . . .

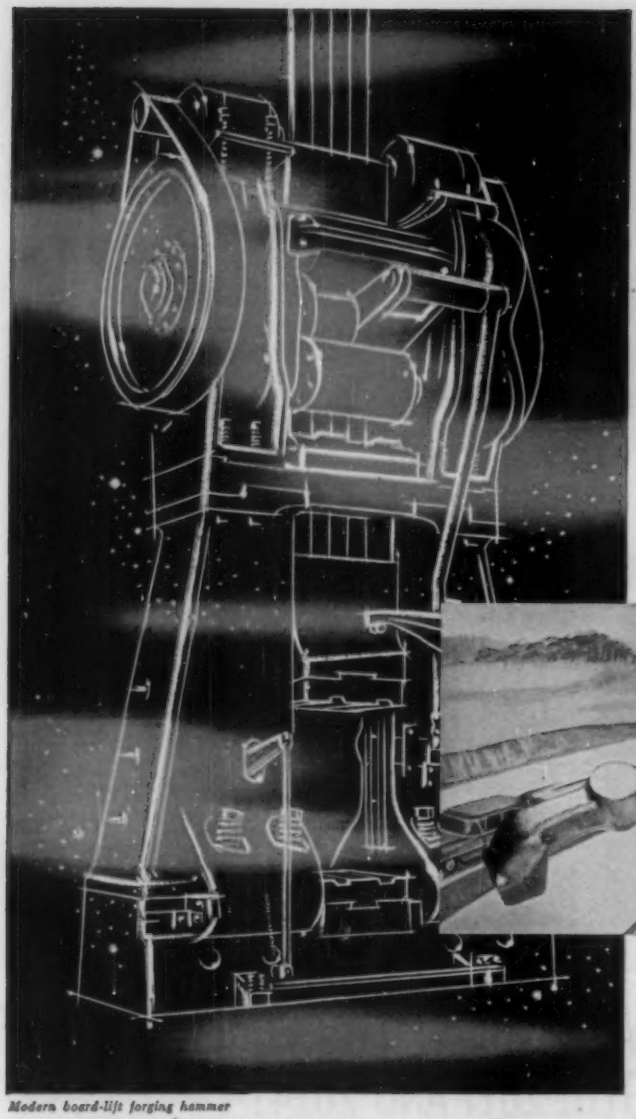
and receptacles in 25 and 250 amp ratings incorporate functional fishtail plug design, two-piece threaded construction, and are offered in red, white, blue, yellow, black and green. All current-carrying parts are gold-plated brass. Superior Electric Co, Dept SPR, Bristol, Conn.

Circle 324 on Reader Service Card

Liquid propellant gas cartridge

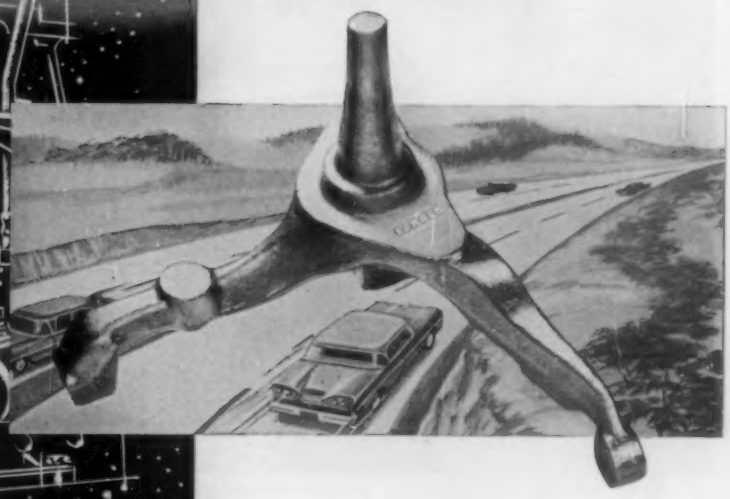
is said to produce high pneumatic pressures in fraction of a second and to be adaptable to operate most pneumatic power-actuated devices. Liquid is monopropellant containing its own oxydizer. Use of liquid propellant as power source

continued on page 91



Modern board-lift forging hammer

SHOCK-STRENGTH of steering spindle soars by designing it to be forged



By designing front-end spindles to be forged, automobile and truck manufacturers practically eliminate danger of failure of these vital parts, even under sudden turning stress that can reach thousands of foot-pounds.

Start your designs by planning to use forgings everywhere there's a high degree of stress, vibration, shock, or wear. Forged parts withstand them all better than parts made by other fabrication methods. And forgings have no hidden voids to be uncovered after costly machining hours have been invested ... the hammer blows or high pressures of the forging process compact the *better* forging metal, make it *even better*.

Write for literature on the design, specification, and procurement of forgings.

When it's a vital part, design it to be FORGED

Drop Forging Association • Cleveland 13, Ohio

Names of sponsoring companies on request to this magazine

CIRCLE 89 ON READER SERVICE CARD

"ALCOA ALUMINUM OFFERS A CHOICE OF TWO SCREW MACHINE STOCK ALLOYS FOR STRENGTH: 2017 AND 2024!"

Precision-made, high-volume screw machine parts cost less in aluminum

Here are the strongest of all Alcoa® Aluminum screw machine alloys. Both will give you superb machinability. Both will give a fine, clean finish. Alcoa Alloy 2017-T4 or -T451 is exceptionally good for deep drilling operations. Alloy 2024-T4 or -T351 offers high shear strength . . . which makes it a popular choice for fasteners and fittings. These alloys will give three times as many parts per pound as other, heavier metals, raise your profits by cutting your over-all unit costs.

Ask your Alcoa distributor or Alcoa sales office for your free *Alcoa Conversion Calculator* . . . which makes cost conversions from brass to aluminum and computes costs quickly . . . and your free *Alcoa Screw Machine Stock Estimating and Operating Data Book*, a comprehensive, easy-to-use book of technical data on aluminum screw machine stock. Get full information on other Alcoa alloys: 2011-T3 or -T8 for faster cutting, 6061-T6 or -T651 for superior finishes, excellent joining characteristics and extra corrosion resistance. Aluminum Company of America, 841-G Alcoa Building, Pittsburgh 19, Pennsylvania.

GET ALL THESE BONUSES WITH EVERY ALCOA ALLOY:

1. Wide range of stock sizes for important price advantages.
2. Guaranteed market for up to 60 per cent of your Alcoa Aluminum turnings and borings.
3. Extensive mill and distributor inventory to meet all requirements.
4. Chamfered ends at no extra cost.
5. Specific 12-ft lengths at no extra cost (for rounds up to 2¾ in.; hexagons up to 2 in.).

ALCOA ALUMINUM

SCREW MACHINE STOCK

offers clean-burning characteristics, low flame temperature, reliable ignition under varied conditions between —109 and 212 F, high-ratio gas expansion from liquid (as high as 14,000:1). Any type of igniter, from simplest percusssion type primer to electronic device, is suitable for use in cartridge. Olin Mathieson Chemical Corp, 460 Park Ave, New York 22.

Circle 325 on Reader Service Card

Sight gravity-feed oiler . . . controls lubrication by needle-valve adjustment. Flow rate is locked by knurled ring-nut once rate has been established and adjusted. Needle-valve adjustment is reported not to be disturbed by toggle-lever shutoff, which is vertical when on and horizontal when off. Uninterrupted metering of oil is achieved by adequate venting. Available with glass and unbreakable plastic reservoirs, each in six standard sizes. Gits Bros Mfg Co, 1866 S Kilbourn Ave, Chicago 23.

Circle 326 on Reader Service Card

Instrument tubing harness . . . has all-black polyethylene core tubes wrapped with mylar tape to protect against penetration and then covered by extruded-vinyl sheath. Core tubes are number-coded in high-visibility white ink. Available in tube combinations of 2, 3, 4, 5, 7, 8, 10, 12, 14, 19 and 37 core tubes. Normal tube sizes are ¼ in. OD x 0.040 in. wall and ⅜ in. OD x 0.062 in. wall. Offered in lengths to 1000 ft and over. Dekoron Products Div, Samuel Moore & Co, Mantua, Ohio

Circle 327 on Reader Service Card

Linear-motion transducers . . . offer sensitivities of 0.2 v and 0.4 v rms/degree. Cylindrical units are 1.25 in. x

continued on page 92

now!

try Retrievable Miniaturization for size in your reproduction department!

THE IDEA. Retrievable Miniaturization is a new ingenious method for reducing the size of prints yet keeping them large enough to be completely readable and usable. Developed by Paragon-Revolute, this method is acknowledged as one of the significant advancements in reproduction.

HOW IT WORKS. In Paragon-Revolute's unique Continuous Reducing Printer and Processor, reduced-size transparencies are made from original drawings for immediate reproduction in blueprint or diazoprint equipment. Reductions can be made as positives or negatives on paper or film. The Printer takes drawings up to 42" wide by any length at speeds up to 30 fpm.

THE ADVANTAGES. Retrievable Miniaturization fits in with existing facilities, calls for no drastic changes in present drafting standards or printmaking systems. It enables savings in materials up to 300% . . . increases capacity of blueprint or diazo-type equipment up to 4 times . . . slashes print handling time, filing space, and mailing costs. Most importantly, it provides readable, usable reduced-size prints without the problems and high cost of blow-back systems.

You owe it to yourself and your company to investigate the advantages and savings offered by this great new concept in reproduction. Use the coupon to get more information or to arrange for demonstration.

The Paragon-Revolute Continuous Reducing Printer is the heart of Retrievable Miniaturization. Really a giant movie camera, it takes pictures of drawings while they move through the machine at speeds variable from 3 fpm to 30 fpm. Camera feeds as easily as blueprint and whiteprint machines.

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☐ Please send me more information about Retrievable Miniaturization.
☐ Please arrange for one of your representatives to contact me about a demonstration.

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Company_____
Address_____
City_____State_____

CIRCLE 91 ON READER SERVICE CARD 91

MPB
announces . . .
3 new R's of
instrument
bearings

Latest additions to the large, fast-growing MPB family are ultra-precision R2, R3, and R4 instrument bearings.

To their many familiar applications such as computers, servos, synchros, gyros and generators, MPB's R Series bearings bring quieter performance, longer life and reduced friction — the results of MPB's advanced production techniques, thorough quality control and constant emphasis on precise, accurate bearing geometry.

R2

Basic material for the R Series is 440C stainless steel. A new type ribbon retainer, for low uniform torque, is available, as are duplexed mountings and preloaded pairs. ABEC Class 7 tolerances maintained in all types and sizes. Standard dimensions are

R3

	Bore	O.D.	Width
R2	.125"	.375"	.156"
R3	.1875"	.500"	.156"
R4	.250"	.625"	.192"

R4

Find out now how MPB bearings and technology can benefit your products. Call your MPB Sales Engineer or write for information. Miniature Precision Bearings, Inc., 207 Precision Park, Keene, N. H.

MPB *Helps you perform miracles in miniaturization*

0.937 in. dia. Designed for standard size 10 servo mounting. Available with ac input and ac or dc output. Typical specifications for size-10 linear-motion, ac-to-dc unit include input range of ±30 and ±60°; input voltage of 26 v ac, 400 cps; output impedance of 5000 ohm; independent linearity of ±0.3%. Useable frequency range is 300 to 3000 cps. Transducers are brushless type. **Arnoux Corp, 11924 W Washington Blvd, Los Angeles.**

Circle 328 on Reader Service Card

Plate-type magnetic separator utilizes magnetic material with intense concentration of magnetic strength adjacent to surface of plate magnets. Hinged case and integral handle facilitates periodic removal of iron from face plate. Suitable for use in chutes, spouts, ducts, feed tables or over screens and conveyors. **Erie Mfg Co, Erie 6, Penna.**

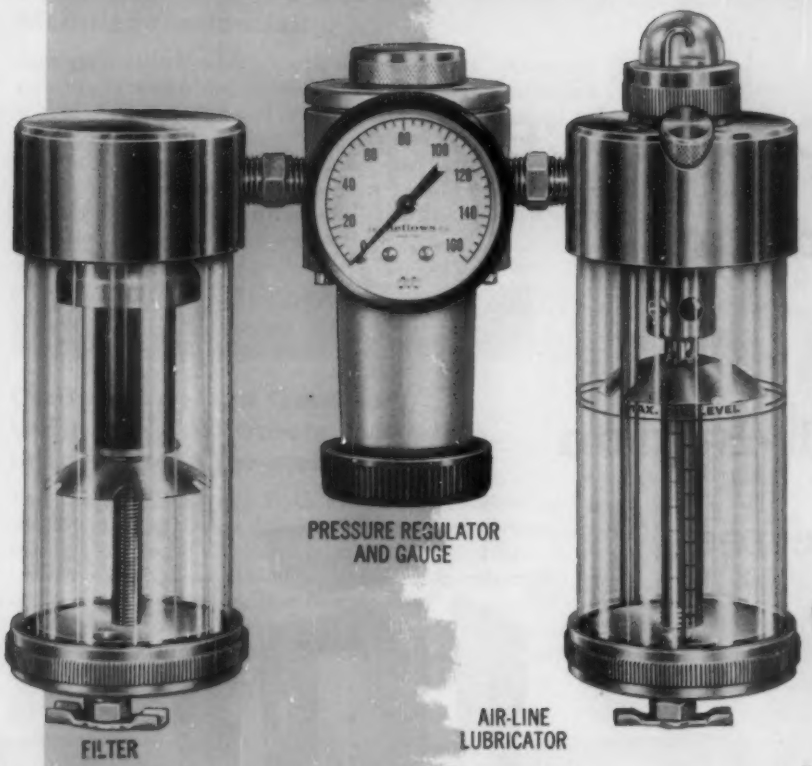
Circle 329 on Reader Service Card

Modular pedestal frame . . . is console-counter-height unit that has been added to line. Tops of front and rear are rounded. Adjustable panel-mounting angles on front and rear are tapped for 10-32 screws on EIA spacings. Brackets are welded in base to accommodate casters. Frame is made of 16-ga steel; angles of 12-ga steel. Finished in gray hammertone. Also available are shelves, end panels and formica writing panels. **Premier Metal Products Co, 337 Manida St, New York.**

Circle 330 on Reader Service Card

continued on page 96

AIR-POWERED EQUIPMENT



PERFORMS MORE EFFICIENTLY

COSTS LESS TO MAINTAIN

GIVES LONGER SERVICE LIFE

with a

Bellows LUBRI-AIR® CONTROL UNIT

HERE'S WHY: Once adjusted to the requirements of a particular air system, the Bellows Lubri-Air Control Unit automatically filters harmful dirt and moisture out of the air stream (40 micron filter element standard; 5, 10 and 20 micron units available) . . . automatically regulates air pressure by compensating for fluctuations in air supply and variation in cfm requirements of pneumatic equipment . . . automatically lubricates air-operated equipment by providing the correct amount of misted oil to the air stream. Bellows Lubri-Air Control Units are available in ¼", ⅜", ½", ¾" and 1" sizes.

Free Bulletin LA-15 gives complete information. Write for your copy today. Address Dept. PE 760. Bellows-Valvair, Akron 9, Ohio.

OTHER INDUSTRIAL DIVISIONS OF IBEC: Sinclair-Collins Valve Co., Valvair, Akron, O., V. D. Anderson Co., Cleveland, Ohio.

675C-3

Bellows-Valvair

The Bellows Co. • Valvair Corp. *Akron 9, Ohio*

DIVISIONS OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

MICRO SWITCH

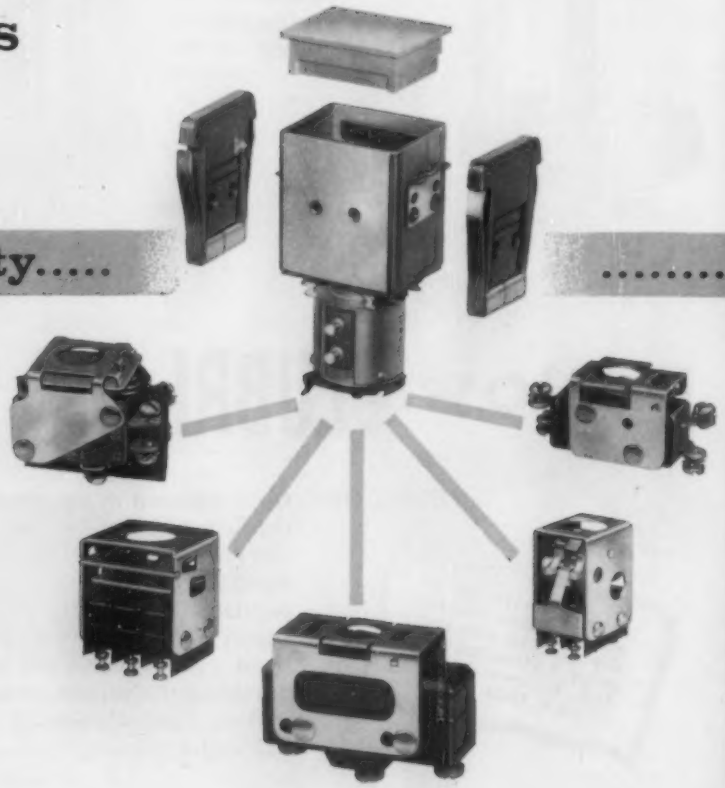
Modular

Lighted

Push-Button

Switches

Reliability..... .....

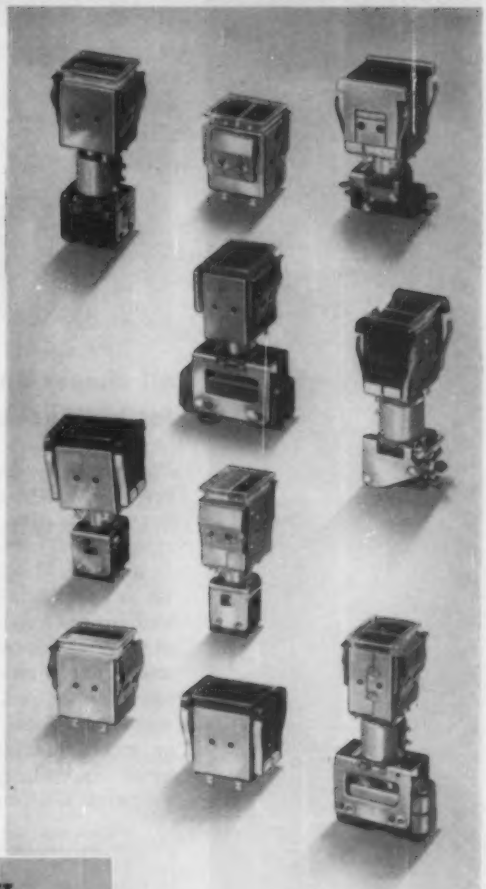


75 YEARS HONEYWELL PIONEERING THE FUTURE

94

PRODUCT ENGINEERING • JULY 18, 1960

MICRO SWITCH Precision Switches



Modular Customizing...

Give your control panel a touch of tomorrow in appearance, the assurance of MICRO SWITCH reliability, and the customizing that will precisely fit your control and display functions. These Series 2 lighted push-button switches perform *both* control and indicator jobs which saves panel space on computers, graphic flow panels, electronic data-processing equipment and many other installations. They simply snap together to fit your styling requirements, then snap into slots in the mounting panel—all without tools.

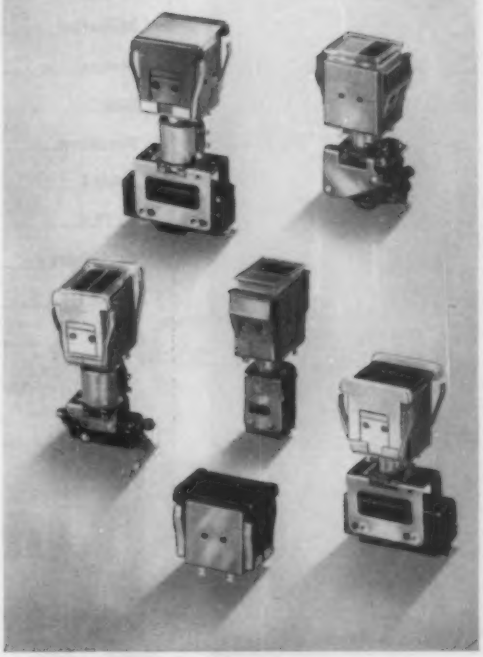
Complete design freedom... units serve as remote indicators only or indicator-switches

You have complete design flexibility. Select from 48 different units and 16 mounting barriers differing in size and color. Forty different color display screens include lateral and longitudinal color divisions. Indicators and operator-indicators are available with 2 or 4 lamps and light output of lamps may be colored by choice of 4 different color filters. You may choose operator-indicator switch units or indicator units only. These modular units meet the very latest requirements for panel design in the field of Human Engineering.

.....and a touch of tomorrow

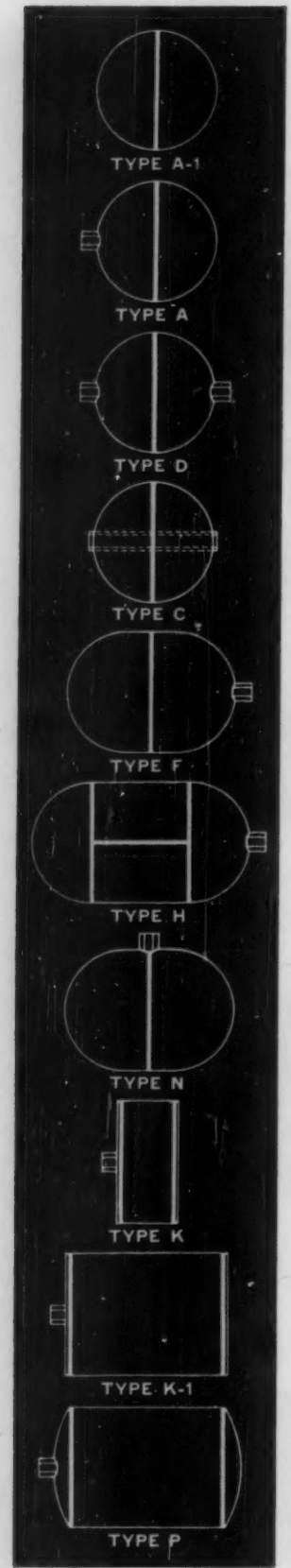
Reliability... from the best in basic switches

The last word in the reliability of your control panel depends on the basic switches used. You can be sure of that reliability with MICRO SWITCH units, and you can choose from eight different series of basic switches to fit your requirements exactly. These include switches for low-energy circuits, for handling D.C. loads up to 10 amperes, 125 volts, and for direct control of A.C. motors of up to two h.p. Alternate-action units, momentary-contact units and others for the control of multiple circuits are also available. Write for Catalog 67 or contact the nearby MICRO SWITCH Branch Office listed in the Yellow Pages.



MICRO SWITCH . . . FREEPORT, ILLINOIS
A division of Honeywell
In Canada: Honeywell Controls Limited, Toronto 17, Ontario

Honeywell
MICRO SWITCH Precision Switches



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all shapes and sizes for high pressure service

For buoyancy mediums, fluid chambers or pressure vessels, Nicholson precision welded floats come *exactly* as you want them . . . spherical, elliptical, cylindrical . . . 2″ to 14″ in diameter . . . and, for working pressures up to 2500 lbs. Float halves are die formed with inward rolled edges, not spun laminated or electrodeposited. *Steel floats* . . . with chromium, cadmium or copper plating . . . with sandblast or pickled finish; *Stainless Steel* and *Monel floats* . . . rough buffed, polished or with smoothly-ground, highly finished welds. Exceptional resistance to pressure and corrosion. Use coupon for more details.

Tell us how you want yours

Material_____

Shape_____

Size_____

Pressure_____

NAME_____

TITLE_____

COMPANY_____

STREET_____

CITY_____ STATE_____

W. H. NICHOLSON and COMPANY
12 Oregon St.
Wilkes-Barre, Pa.

NICHOLSON
of Wilkes-Barre

Four-post drafting tables . . . with steel drawers and pedestal drawing tables with positive-lock tilt to prevent board slippage are offered in total of 11 models. Hardwood bases are steel reinforced. Drafting tables also offers three-receptacle electrical outlet with cord. Board sizes range from 37½ x 48 in. to 43¼ x 84 in. Pedestal drawing tables feature spring-loaded control for board setting at any angle. Board sizes range from 31 x 42 in. to 43¼ to 84 in. Stacor Equipment Co, 295 Emmet St, Newark 5, NJ.

Circle 331 on Reader Service Card

Ac vacuum-tube voltmeter . . . measures ac sine-wave voltages from 0.2 milliv through 300 v rms with frequency response 10 cps through 400 kcps. Meter scale provides db marking on both voltage-range positions and meter scale. Instrument is said to have accuracy of 5% of full scale. Incorporates high input impedance, multivoltage range and wide frequency response. Suited for general-purpose applications. Simpson Electric Co, 5200 W Kinzie St, Chicago 44.

Circle 332 on Reader Service Card

Plastic four-bevel scales . . . for the architect and engineer are lightweight, have four beveled white edges and are packed in vinyl cases. Engineers' scale features graduations in decimal points to the inch; full divided throughout; 10 and 50, 30 and 40 parts to the inch. C-thru Ruler Co, 827 Windsor St, Hartford, Conn.

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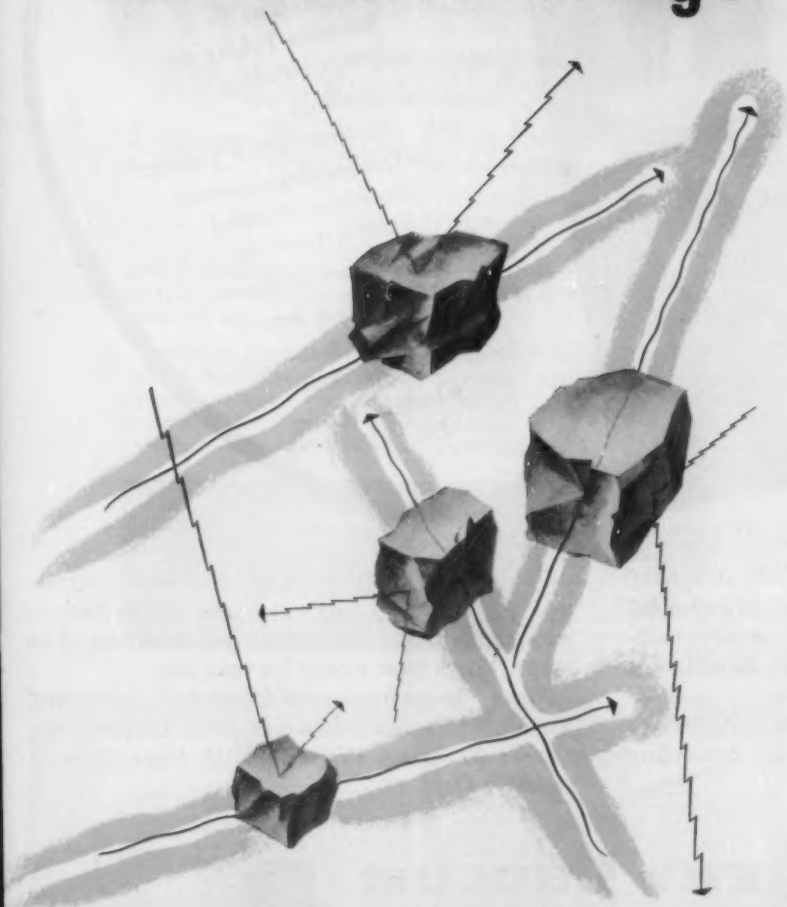
Outstanding
by Nature...
Improved
by NORTON...

MAGNORITE* Fused MgO



The inherent capabilities of magnesium oxide are vastly improved by Norton Company processing. Selected grades of magnesia are transformed in our electric furnaces into high purity MAGNORITE fused magnesium oxide — a crystalline material with extremely useful chemical and physical properties.

Norton MAGNORITE fused MgO is available in a complete range of grades, granular sizes and in a variety of fired shapes. For example, one top grade offers the following properties: *High Electrical Resistivity (10^8 ohm-cm at 900°C). High Melting Point (2800°C). Good Thermal Conductivity (0.023 Cal • Sec^{-1} • Cm^{-2} • $°C^{-1}$ at 700°C). High Chemical Purity (99.5% MgO). High Chemical Stability with Most Metals. Readily Crushable. Easily Packed to High Densities.*

MAGNORITE fused MgO is the world's most widely used brand . . . for containing special metal melts and keeping them free from impurities . . . as insulation for thermocouples and sheathed electrical heating elements . . . as an ingredient of ceramic electronic components. Infrared transmission through single crystals is excellent. And these are just a *few* of the uses for this versatile material.

Investigate *all* of the advantages of MAGNORITE fused MgO and how it can benefit your product or process. Write regarding *your* specific application and for complete details. NORTON COMPANY, 226 New Bond St., Worcester 6, Massachusetts.

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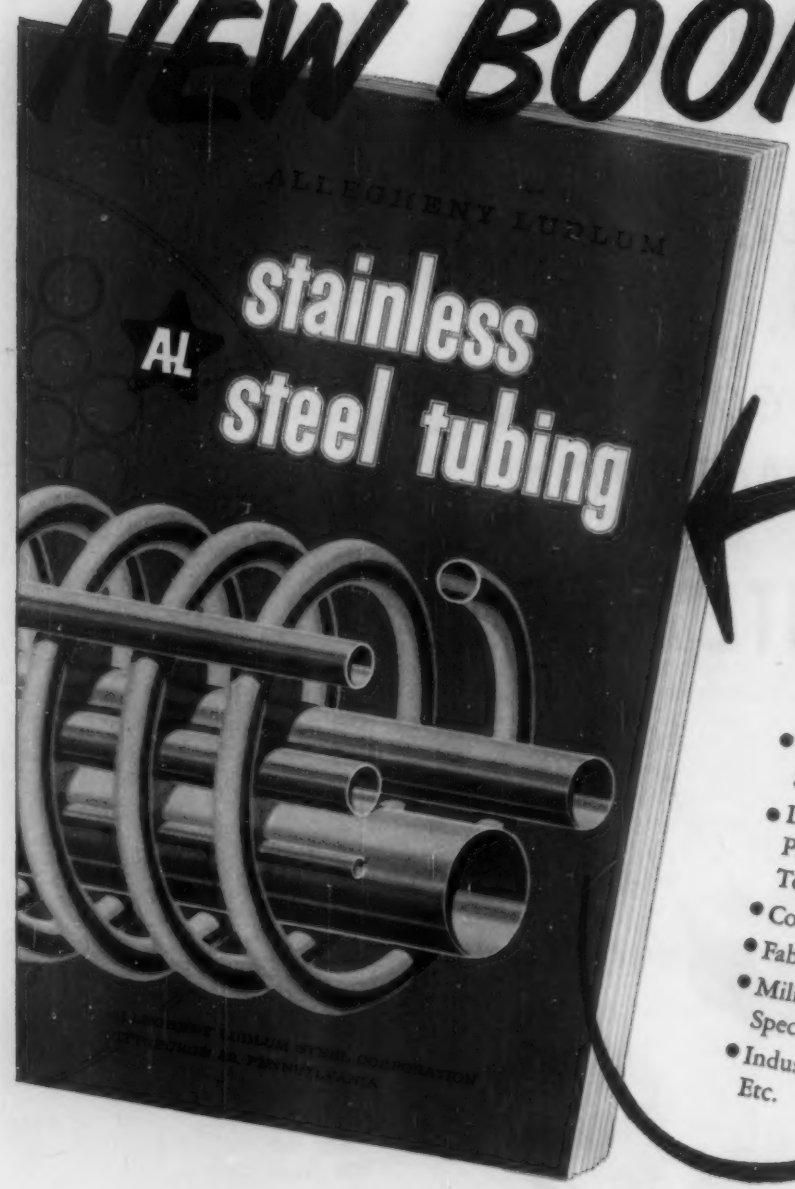
NEW BOOKLET on STAINLESS STEEL TUBING sent on request



PARTIAL LIST OF CONTENTS

- Stainless Steel grades
- Product data on Seamless Tubing and Welded Tubing
- Size range Stainless Pipe & Tubing
- Design data—Internal Pressures—Elevated Temperatures, etc.
- Corrosion resistance
- Fabrication data
- Military & Aircraft Specifications
- Industry's uses

Etc.

This 36-page booklet newly published by Allegheny Ludlum is packed with technical data and authoritative information on both welded and seamless stainless steel tubing. There are more than 20 tables for ready reference and many photographs.

It will be helpful to design engineers and others interested in solving the many critical and demanding pipe and tubing applications.

The booklet contains the best and latest information available on product and design data on the subject—the partial contents listed give some idea of its scope. You'll want a copy for your files.

Write for your free copy of Allegheny Stainless Steel Tubing, *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pennsylvania. Address Dept. PE-7.*

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ALLEGHENY LUDLUM

Export distribution: AIRCO INTERNATIONAL

EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

A three-deck 48" SWECO Separator used by a prominent chemical company in screening granular alkali to exact sizes. Using Marman quick-opening couplings, screens are easily changed to obtain any desired product size.

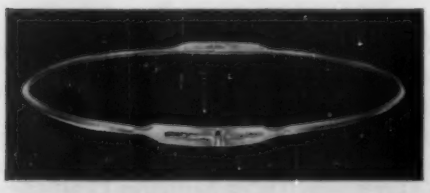
"We Use MARMAN Couplings for Easier Screen Changes on SWECO Separators"

Reports R. J. McCausland, Chief Engineer, Vibro-Equipment Division, Southwestern Engineering Company of Los Angeles

SWECO Separators are used throughout industry for fast, efficient and economical screening of food, chemicals, sand and gravel.

For years, Southwestern has relied on Marman's line of Band Couplings to join Separator components because they reduce assembly costs. Marman's "quick-coupler" latch design makes servicing easy and cuts labor by permitting rapid screen changes for users of SWECO Separators.

Marman has the coupling designs and experience to help solve almost any clamping, holding or fastening problem for manufacturers using any type of container, filter or similar device. Outline your requirements to us, or write today for full information about Marman's complete line of clamps, straps, couplings and joints.



Aeroquip

MARMAN DIVISION

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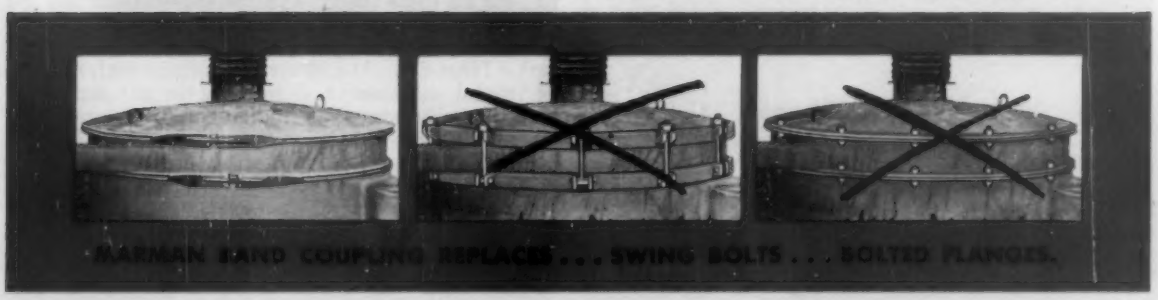

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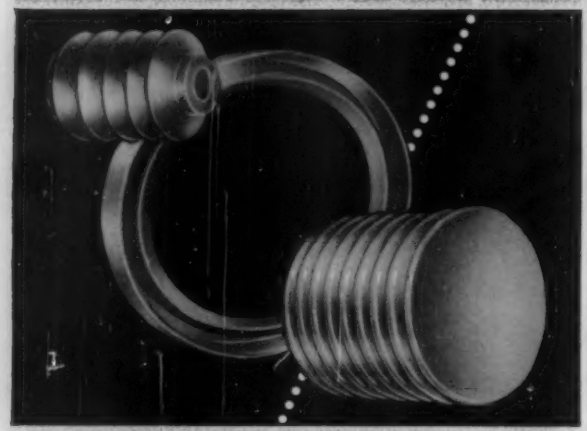

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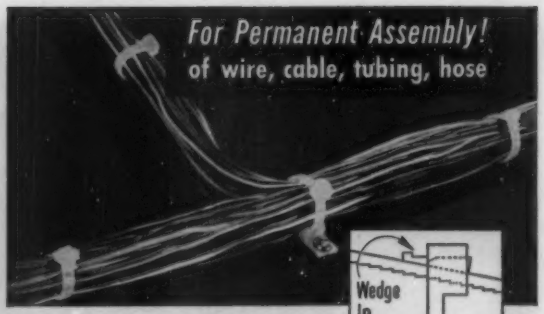

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DESIGN LITERATURE

Metalizing of Plastics

HAROLD NARCUS. Reinhold Publishing Corp, 430 Park Ave, New York 22. 5¼ x 7¾, 208 pp, $5.50.

This book presents details for carrying out every commercial metalizing process for plastics or other nonconductors. These processes include the copper-film process, the deposition of "electroless" nickel coating, a review of the new molded conductive plastics, "gas" plating, the deposition of thick evaporated films and many, many others. The author includes numerous illustrations showing the latest equipment being used in the newer processes, and recent advances in the field receive special attention.

Electrical Power Sources Volume II—Batteries

EMIL J HELLUND, PhD, Plasmadyne Corp, Santa Ana, Calif. PB 161262, Office of Technical Services, Dept of Commerce, Washington 25, DC. 8 x 10½, 97 pp. $2.25.

Summarizes battery performance characteristics, structure, power-weight ratios, power-volume ratios, behavior at low temperatures, unactivated shelf life, activated shelf life, rechargeability, reliability, open-circuit voltage, average operating voltage, and adaptability for particular service for all chemical batteries, including fuel cells and nuclear batteries. Included in coverage are Bacon cell, cadmium silver oxide, dynox 95, indium, Lalande cell, lead-acid, Leclanche, magnesium silver chloride, mercury, nickel-cadmium, nickel-iron, silver-zinc, solid ion, strontium, and tellurium. (Full title: "Fundamental Investigations of Electrical Power Sources – Volume II – Batteries.")

Radiation Pyrometry And Radiant-heat Transfer

THOMAS R HARRISON. John Wiley & Sons Inc, 440 4th Avenue, New York 16. 6 x 9, 234 pp. $12.

Analyzes and solves many technical questions concerning use of radiation pyrometers in industry, giving both theoretical and practical principles of radiation pyrometry.

First three chapters have unified discussion of laws of emission, absorption, reflection, and transmission of thermal radiation, applicable to the field of radiant-heat transfer as well as radiation pyrometry. The remaining chapters include important descriptions and mathematical analyses of physical and operating characteristics of radiation pyrometers. Extensive tables are at end. (Full title: "Radiation Pyrometry and Its Underlying Principles of Radiant Heat Transfer.")

Control System Analysis and Synthesis

D'AZZO and HOUPIS. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 6 x 9, 580 pp. $13.50.

The text—for college undergraduates and graduates—begins by presenting the principles of obtaining differential equations for electrical, mechanical, hydraulic, and heat-flow systems. This is followed by the classical solution of differential equations. The Laplace-transform approach is used, and the block-diagram method is shown. Basic servo characteristics are discussed in detail.

Various methods of analysis are then taken up: root locus and frequency techniques (Nyquist's stability criterion). The same system is used with each method for ease in correlating the results. Compensation techniques are presented for each method to improve performance. Other topics included are optimum response, nonlinearities and computers. The last chapter includes some experimental techniques, and ties together all the methods presented in the book.

ABSTRACTS FROM THE LITERATURE

Permanent Magnets

Seven tables of materials are included.

"How to Select Permanent Magnet Materials," R. H. Warring. Engineering Materials and Design, April '60, Drury House, Russell St, London, WC 2, England.

6 Transducers for Positioning

Six high-precision transducers with measurement capabilities up to one part in a quarter million are described. Types described and illustrated are: Pin-and-paul mechanism, magnetic

continued on page 103

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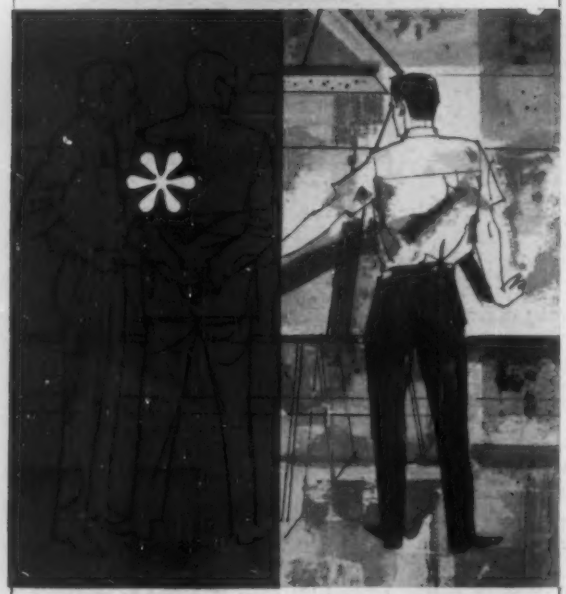

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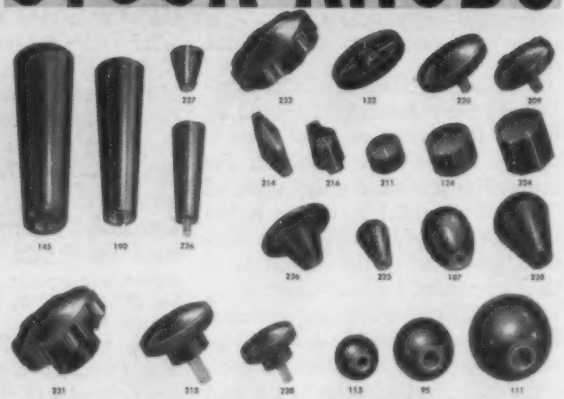

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bench-mark system, resolver-type transducers, electrostatic disks, coded-disk transducer, diffraction gratings.

"6 Transducers for Precision Position Measurement," John O. Morin, Concord Control Inc. Control Engineering, May '60, 330 W 42nd St, New York 36.

Electrical-discharge Machining

Little information has been reported on the effects of an electrical-discharge-machined surface on the mechanical and chemical properties of the workpiece material. There is a need for quick and inexpensive electrodes. This paper presents the research and development work that has been conducted in an attempt to resolve some of these problems.

"Recent Developments in the Theory and Application of Electrical-discharge Machining," George G. Bott, Grumman Aircraft Engineering Corporation. ASTE Technical Paper #220, American Society of Tool Engineers, 10700 Puritan Ave, Detroit 38.

Contactless Relays

Discusses various ways in which semiconductor-based relays can be built, and how their design is affected by their use.

"Designing and Applying Contactless Relays," R. N. Auger, Automatic Control, June '60. 430 Park Ave, New York 22.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

FIBERGLASS MOLDING—Booklet, 24 pp. Covers technique, properties and test characteristics, designing, fabrication and finishing methods. G B Lewis Co, 426 Montgomery St, Watertown, Wis.

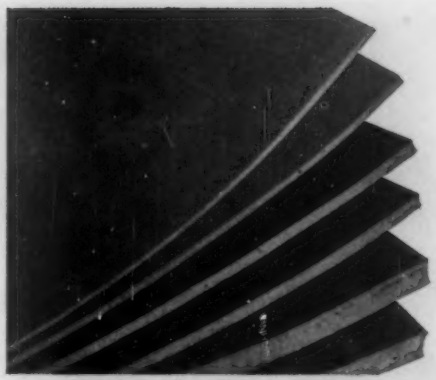
Circle 350 on Reader Service Card

AUTOMATION COMPONENTS AND CONTROL SYSTEMS—Condensed catalog D-31, 26 pp. Presents timing components and linear measuring systems for industrial and military users. Standard timers and counters are reviewed, with specifications and characteristics. Automatic Timing & Controls Inc, King of Prussia, Penna.

Circle 351 on Reader Service Card

STEPLESS VARIABLE-SPEED DRIVES—Catalog ZM-400C560, 16 pp. Describes various units, with or without motor, in the 400 series of drives for fhp applications. Typical applications are listed and pictured. Operating features and installation

continued on page 106



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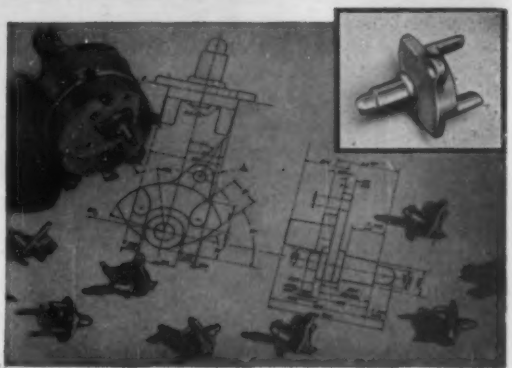

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REV-LOK eliminates feedback torque, provides two-directional positioning, drive, over-running and backstopping

NOW! You can have positive and instantaneous stopping of feedback (reverse) torque—it will never reach the driving equipment. For, the complement of sprags in this new Formsprag device is divided into two opposing sets that: instantly stops feedback from either direction, assures equalized radial loading, evenly distributes wear for longer life, and provides multi-contact surfaces for greater holding strength when high feedback torque occurs.

When the device is mounted with the outer race in a fixed position, feedback is stopped by wedging of sprags between output member and I.D. of fixed outer race —feedback never reaches the input shaft. Yet, this new design permits free rotation and transmission of high driving torque in either direction from input to output shaft. Current catalog models are available in ratings up to 30,000 lbs/in. and with bore diameters to 2½".

When used as a two-directional over-running clutch, output shaft member is mechanically secured against rotation and outer race then becomes the output member. A slight right or left rotation of input shaft disengages either set of sprags and determines direction of drive, over-running and backstopping.

This versatile device can also be used for two-speed drive and reversing applications. By connecting a low-speed reversible motor to outer race and a high-speed motor to input shaft member, driving torque can be transmitted at two speeds or reversed.

Smallest standard Rev-Lok sizes (⅜" and ¼" shaft diameters, 96 lbs/in. output and holding capacity) have the following additional features: mounting flange on outer race, end-to-end or coaxial drive, completely enclosed and permanently lubricated, economical sleeve bearings and roller type contacts.

Rev-Lok devices not only drive, position, over-run and backstop in two directions, but they also provide automatic, instantaneous and positive prevention of feedback from driven equipment to power source. They are compact, have greater torque capacity for their size and weight and permit higher over-running speeds than any similar device. Formsprag technical paper provides further details on operation and features, send for your free copy.

FORMSPRAG COMPANY, 23607 Hoover Road, Dept. 105R, Warren (Detroit), Michigan
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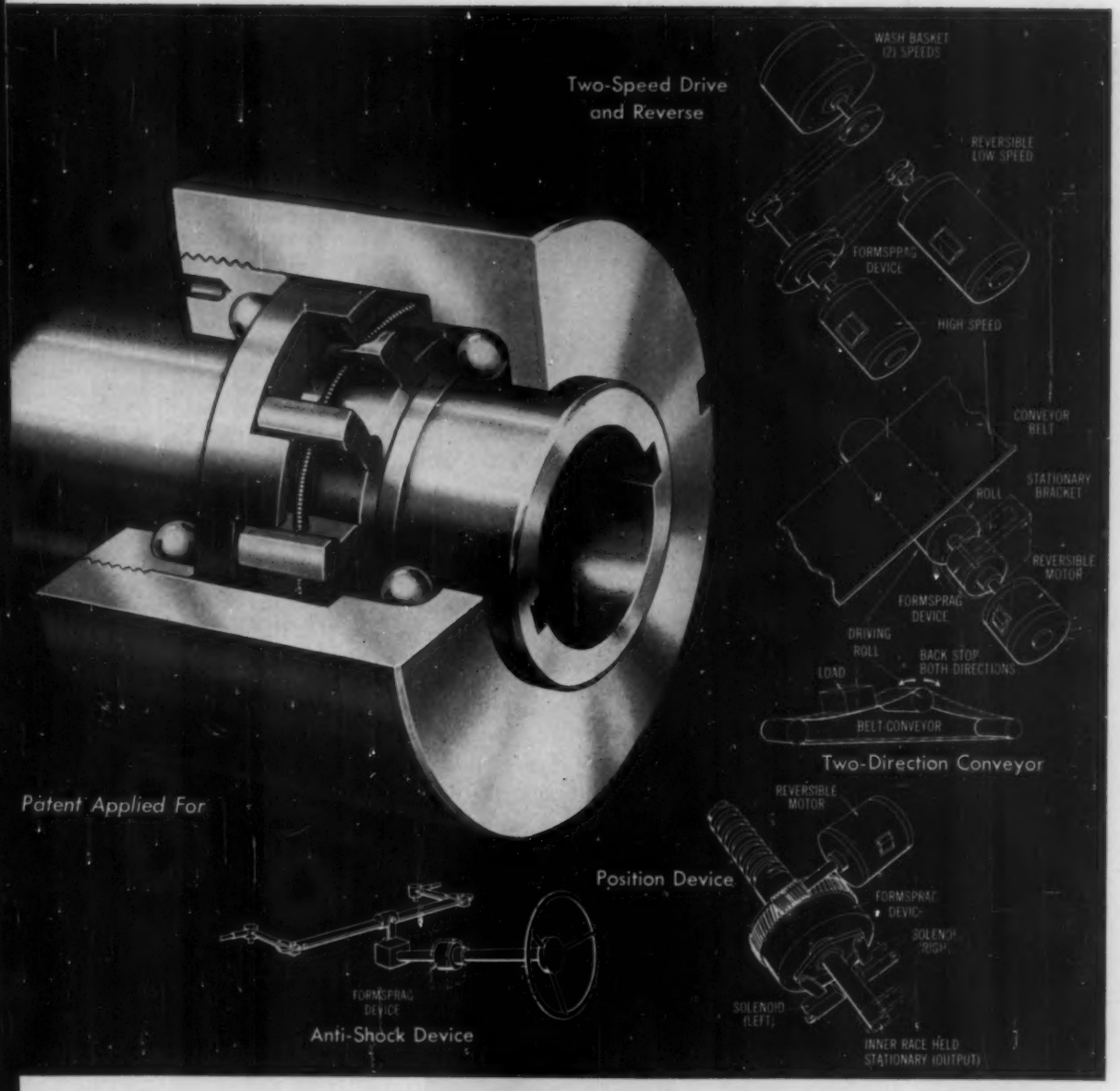
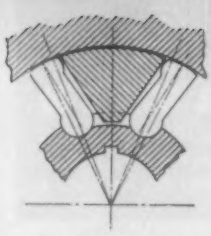
FORMSPRAG COMPANY

Precision Power Transmission Products



BECAUSE there is a complement of sprags arranged in opposing pairs, there is always a multiple number of contact surfaces engaging the outer race when feedback or backstopping conditions are present. This provides equalized radial loading and strong holding torque against even unusually heavy feedback.



The entire complement of sprags, which is a part of the output member assembly, rotates at driving speed while outer race remains stationary. Thus, sprags are in light contact with the outer race and are always in position to pick up the feedback load at constantly changing points on the outer race. This design feature assures longer life through even distribution of wear over entire surface of outer race. With sprags in constant contact with outer race, any independent movement of output shaft causes instantaneous locking of sprags—there is no backlash on output shaft.

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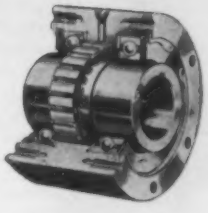

When should COST be a factor in design investment?

The importance of cost control to any business operation cannot be minimized. However, when related to design investment — the time, money and materials spent to create new products, or to revise present products — *cost-saving becomes expensive if quality is sacrificed to price!*

Any investment in product design should be made to gain a competitive advantage, and component parts chosen to hold that competitive edge. Any deviation gives others an opportunity to take the lead.

It's only logical then, that all cost-saving suggestions in design investment must be evaluated as to effect on finished products. Sales and profits — and industry leadership — depend on such serious consideration.

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ELECTRIC MOTOR ENGINEERING, INC.
Los Angeles, Calif. (OLive 1-3220)
Oakland, Calif.
WINSLOW ELECTRIC CO.
New York, N.Y. • Chester, Conn.
Philadelphia, Penn. • Cleveland, Ohio

suggestions are accompanied by diagrams and tips on power transmission. Zero-Max Co, 1952 Lyndale Ave S, Minneapolis 5.
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HIGH-DENSITY POLYETHYLENE—Brochure, 20 pp. Illustrates 101 applications of this plastic. Brief description of the finished article and its method of fabrication accompanies each photograph. W R Grace & Co, Polymer Chemicals Div, 225 Allwood Rd, Clifton, NJ.
Circle 353 on Reader Service Card

FASTENERS FOR ELEVATED-TEMPERATURE USE—Catalog 286, 12 pp. Specifications and characteristics of fasteners fabricated to AMS-5735 for 1300 to 1800 F applications. Mercury Air Parts Co Inc, 9310 W Jefferson Blvd, Culver City, Calif.
Circle 354 on Reader Service Card

PROCESS CONTROLS—Catalog 4-60, 12 pp. Describes and illustrates various industrial instruments and controls. Instruments Inc, PO Box 556, Tulsa, Okla.
Circle 355 on Reader Service Card

ELECTRONIC COOLING EQUIPMENT—Short-form catalog, 16 pp. Highlights features and applications of 19-in. rack-mounted, packaged fans and blowers. Over 80 models are included in line. McLean Engineering Laboratories, Box 228, Princeton, NJ.
Circle 356 on Reader Service Card

ELECTRIC MOTORS—Condensed motor data and price bulletin 150, 14 pp. Dimensions, ratings, characteristics and prices of standard and special motors for fhp and integral-hp applications. Doerr Electric Corp, Cedarburg, Wis.
Circle 357 on Reader Service Card

MINERAL-INSULATED THERMOCOUPLES—Catalog G-100-4, 12 pp. Outlines specifications of small-diameter, mineral-insulated thermocouples. Covers bulk material, elements and complete assemblies. Minneapolis-Honeywell Regulator Co, Industrial Div, Wayne and Windrim Aves, Philadelphia 44.
Circle 358 on Reader Service Card

OPTICAL QUARTZ GLASS—Bulletin 5241, 12 pp. Covers properties, characteristics and performance information on optical-quality fused quartz or fused silica. Translated from a paper by Dr H Mohn. Engelhard Industries Inc, Amersil Quartz Div, 685 Ramsey Ave, Hillside 5, NJ.
Circle 359 on Reader Service Card

CLUTCHES AND BRAKES—Brochure, 8 pp. Explains operating principle, describes several applications, outlines operat-

continued on page 109

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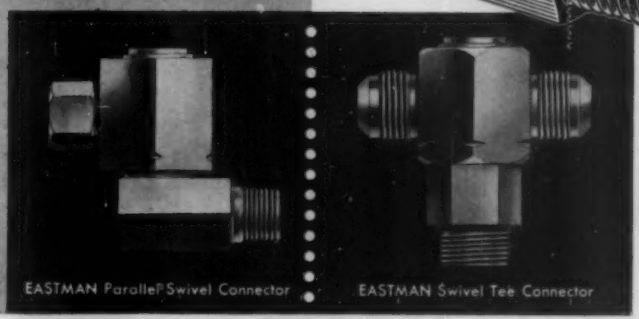

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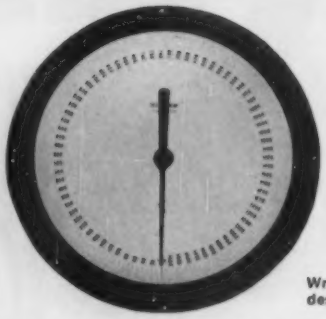

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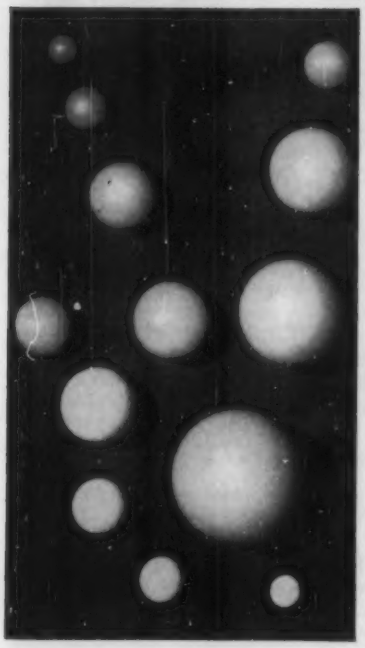

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DESIGN LITERATURE.....continued

ing advantages and includes torque ratings and package dimensions. Warner Electric Brake & Clutch Co, P-78, Beloit, Wis.
Circle 360 on Reader Service Card

CONNECTORS WITH REMOVABLE CONTACTS—Brochure, 6 pp. Specifications, dimensions and description of method of wiring contacts for plastic molded connectors. DeJur-Amsco Corp, 45-01 Northern Blvd, Long Island City 1, NY.
Circle 361 on Reader Service Card

SWITCH ACCESSORIES AND SPECIAL CONTROL EQUIPMENT—Catalog 57-S7, 12 pp. Circuits and specifications for switches, features and descriptions of control equipment. Automatic Switch Co, Florham Park, NJ.
Circle 362 on Reader Service Card

SWITCH AND THERMOSTAT PACKAGES—Bulletins PRSW-10 and THSN-26A, 4 pp each. Typical configurations illustrate packaging facility in the design and production of custom switch actuators, custom temperature controls and special-design configurations. Spencer Products Group, Texas Instrument Inc, Metals & Controls Div, 34 Forest St, Attleboro, Mass.
Circle 363 on Reader Service Card

INSULATING CHANNEL AND ANGLE STOCK—Folder, 6 pp. Gives dimensions and applications for 10 sizes of insulating channel and angle stock. Glastic Corp, 4321 Glenridge Rd, Cleveland 21.
Circle 364 on Reader Service Card

COATINGS SELECTOR—Guide, 6 pp. Aids in selection of specialty coatings for use on plastics, metals, glass and wood. Charts show uses and characteristics of coating materials, coatings and formulations. Bee Chemical Co, Logo Div, 12933 S Stony Island Ave, Chicago 33.
Circle 365 on Reader Service Card

INDUSTRIAL TUBES—Handbook, 8 pp. Lists some 900 tube types together with Raytheon direct replacements and electrical equivalent types. Raytheon Co, Waltham 54, Mass.
Circle 366 on Reader Service Card

MILITARY AND SPECIALTY CASTERS—Folder 42060, 6 pp. Specifications and features of swivel-plate and rigid-plate caster in single- and dual-wheel types. Faultless Caster Corp, Dept PR-222, Evansville 7, Ind.
Circle 367 on Reader Service Card

PANEL-MOUNTING BLOWERS—Catalog 201, supplement C, 4 pp and price list. Covers line of blowers for cooling

continued on page 111

(Advertisement)

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See Sweet's 1960 Prod. Des. File, 7/E

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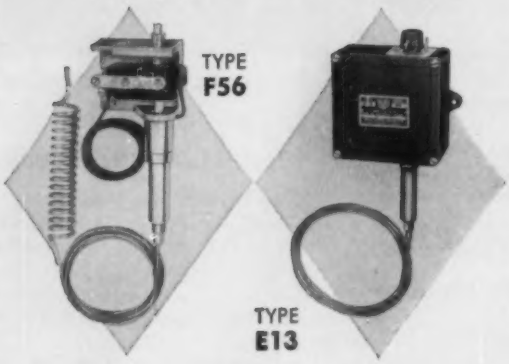

The F56 and E13 are functionally similar controls. Type F56 is a wide range, uncalibrated, skeleton unit designed for use in ovens, incubators, and other applications where space or weight is a limiting factor. Type E13 is a narrow range, calibrated, enclosed unit intended for similar applications but under conditions where an enclosure and external adjustment knob and dial are desirable. Explosion proof unit, Type E98, is also available.

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FLAT-TOP CONVEYOR CHAINS—Bulletin 6061, 4 pp. Outlines operating advantages of various flat-top chains. Chain Belt Co, Milwaukee 1.
Circle 369 on Reader Service Card

STRIP TUBING—Brochure, 8 pp. Describes seamless, light-wall tube that is processed in strip form. Outlines economies of packing, shipping and storing and explains technique used to expand strip into tubular form. Wolverine Tube, Div Calumet & Hecla Inc, 17200 Southfield Rd, Allen Park, Mich.
Circle 370 on Reader Service Card

257 F CYLINDRICAL CAPACITORS—Bulletin GEA-7085, 4 pp. Covers electrical performance, construction features and rating of foil capacitors. Life-test tables compare capacitance and power factor vs time. General Electric Co, Schenectady 5.
Circle 371 on Reader Service Card

PUMP WITH INSTANT CONTROL—Leaflet O8B9548, 2 pp. Describes pump with instant control for variable capacity and head requirements. Cross-section diagrams show operation of pump's pneumatic control system. Allis-Chalmers, Milwaukee 1.
Circle 372 on Reader Service Card

BERYLLIUM TUBING—Data memorandum 26, 4 pp. Gives information on available sizes and properties of pure beryllium tubing. Superior Tube Co, 1556 Germantown Ave, Morristown, Penna.
Circle 373 on Reader Service Card

PACKING SELECTION—Chart, 2 pp. Recommends proper packing types to choose for specific applications. Raybestos-Manhattan Inc, Packing Div, Passaic, NJ.
Circle 374 on Reader Service Card

FORCE-CONTROL SWITCH—Bulletin 49E, 6 pp. Describes line of force-control switches that operate in compression or tension and which can trigger as many as four separate operations. W C Dillon & Co Inc, PO Box 3008, 14620 Keswick St, Van Nuys, Calif.
Circle 375 on Reader Service Card

LOW-TORQUE BEARINGS—Data sheet D-3, 2 pp. Dimensions, size and design characteristics of electromagnetically-powered ballbearing assembly, which operates as a practical support member with low restraining-torque characteristics. Barden Corp, 200 Park Ave, Danbury, Conn.
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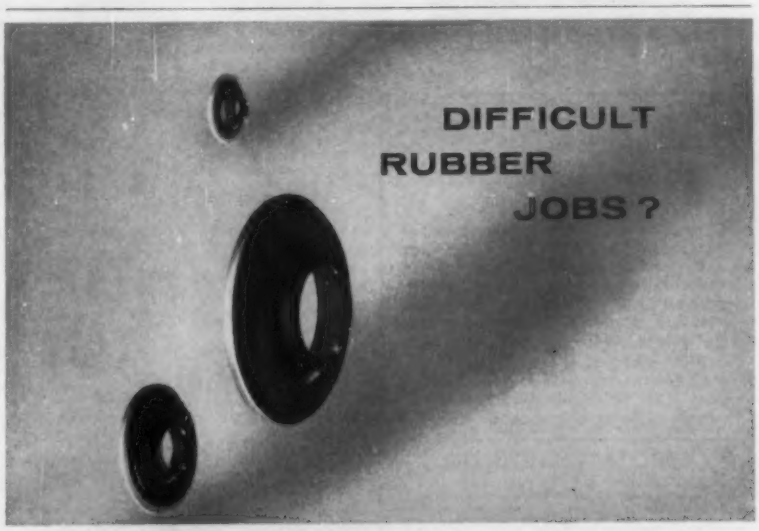

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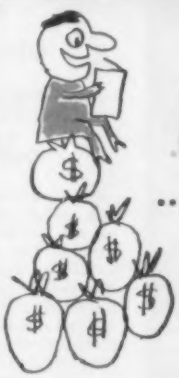

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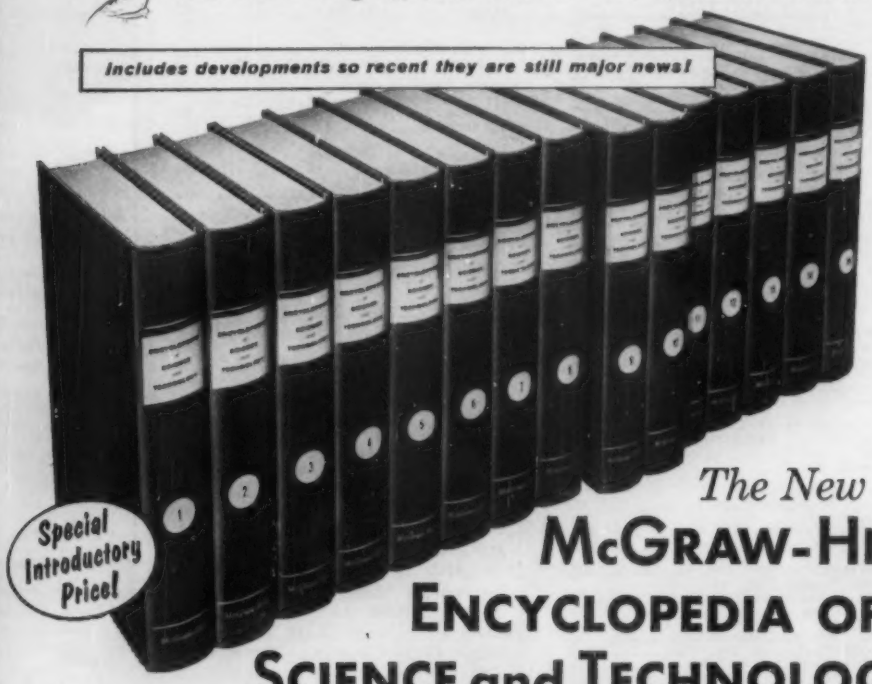

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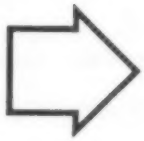

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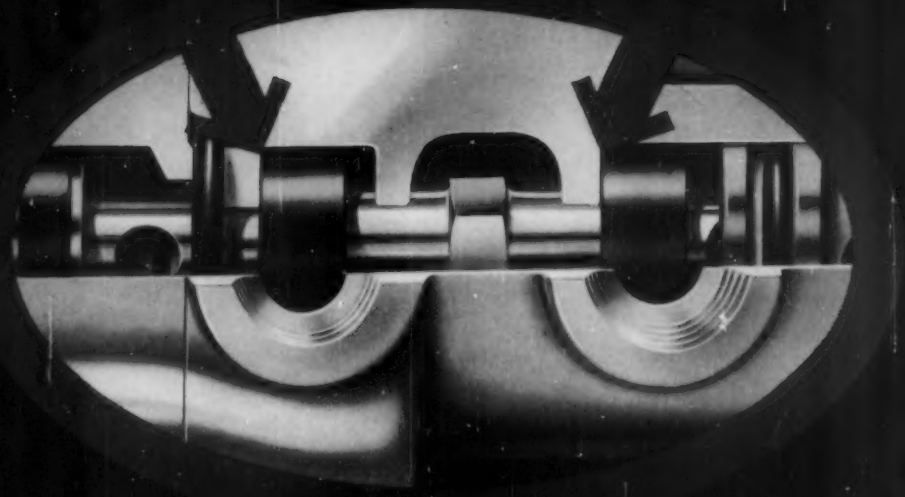

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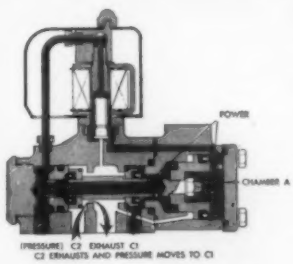

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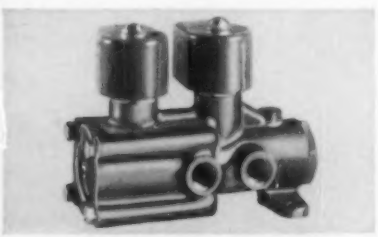

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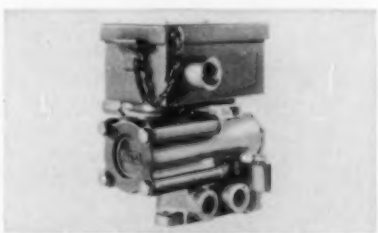

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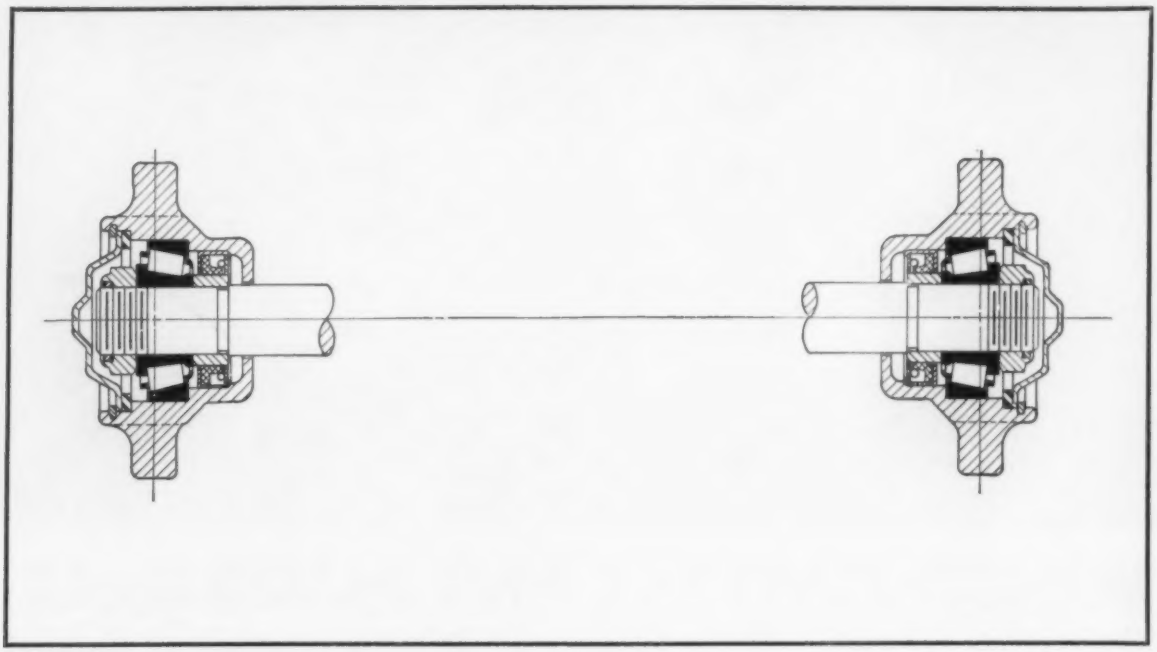

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